

**FLORIDA GEOLOGICAL SURVEY
FOURTEENTH ANNUAL REPORT**

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FLORIDA STATE GEOLOGICAL SURVEY

HERMAN GUNTER, STATE GEOLOGIST

FOURTEENTH ANNUAL REPORT

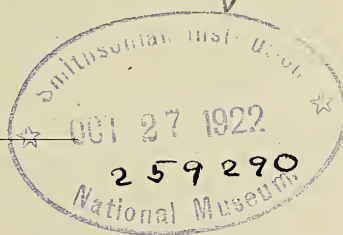
1921-1922

ADMINISTRATIVE REPORT

MINERAL INDUSTRIES

PETROLEUM POSSIBILITIES

Including a Geologic Map of Florida



PUBLISHED FOR
THE STATE GEOLOGICAL SURVEY
TALLAHASSEE, 1922

ST. AUGUSTINE, FLA.
THE RECORD COMPANY
1922

LETTER OF TRANSMITTAL.

To His Excellency, Hon. Cary A. Hardee, Governor of Florida:

SIR:—In accordance with the law establishing the State Geological Survey I submit herewith my annual report, which is the Fourteenth in the series of annual reports thus far published by this Department. The report contains the administrative section, which briefly sets forth the activities of the Survey, statistics on the mineral production for the years 1919 and 1920 as well as such recommendations as it appears urgently necessary to make. In addition, the report contains a paper entitled "On the Petroleum Possibilities of Florida," accompanied by a general geological map of the State.

The last-mentioned paper was prepared to supply information to the increasing number of persons requesting data on this subject. Owing to his peculiar fitness, Dr. E. H. Sellards was engaged to prepare this report. In the capacity of State Geologist for a period of almost twelve years, he became intimately familiar with the geology of Florida. His work for the Bureau of Economic Geology and Technology of Texas—one of the greatest oil-producing states—furthermore has afforded special opportunity for the study of petroleum geology. And it is hoped the report may serve, in a measure, to direct future oil prospecting.

Your cordial interest in the work of this Department is fully appreciated and I thank you for it and for all assistance rendered.

Very respectfully,

HERMAN GUNTER,
State Geologist.

April, 1922.

TABLE OF CONTENTS.

	PAGE
Administrative Report	5
Introduction	5
Purpose and Plan of the Survey.....	6
Museum	9
Work in Progress	9
Work Provided For	10
Co-operation with the United States Geological Survey.....	10
Co-operation with other Departments	11
Future Investigations and Plans	12
Topographic Mapping	12
Water Powers	12
Geography and Vegetation of the State.....	12
Limestones	13
Sands	13
Recommendations	14
Value of Cuttings from Wells.....	14
Conservation of Underground Water Supply.....	14
Additional Funds Needed	15
Financial Statement	16
Mineral Production in Florida During 1919.....	20
Statistics on Mineral Production During 1920.....	26
On the Petroleum Possibilities of Florida, by E. H. Sellards and Herman Gunter (with Figs. 1-9, and geologic map)	33

ADMINISTRATIVE REPORT.

HERMAN GUNTER, STATE GEOLOGIST.

INTRODUCTION.

The State Survey force since the publication of the last annual report, in addition to the State Geologist, has been Dr. R. M. Harper, whose services terminated in April, 1921, and Mr. M. K. Cooke, whose services began August 15, 1921. Mr. Sam Cobb has also been employed during spare hours and has assisted in mailing out reports, arranging specimens and attending to other details about the office and museum. By special arrangement, Dr. E. H. Sellards, formerly State Geologist, rendered temporary services to the Survey and has prepared the accompanying report on the petroleum possibilities of the state.

Dr. Harper completed the preparation of the report on the Geography of Central Florida, which was published in the Thirteenth Annual Report, 1921. Mr. Cooke is engaged in the preliminary preparation of a revision of the reports on the water supply of the state, and much of his time has been spent in the field. In addition, he has assisted in cataloging and recording Survey specimens.

The State Geologist, besides his manifold executive, editorial and consultive duties, has had those of a secretary-stenographer. The work is a detail that should not burden the executive, but in August, 1920, the services of a secretary were dispensed with on account of the limited appropriation for the work of the Survey. In addition, the State Geologist has assisted in the preparation of the report on the petroleum possibilities and the geological map accompanying that report.

PURPOSE AND PLAN OF THE SURVEY

The State Geological Survey was established by the Legislature of 1907. Section 3 of the Act gives a broad definition of the purpose of such Survey and specifies that investigations shall be made regarding the "minerals, water supply and other natural resources of the state," and further stipulates that there shall be included "in such report full description of such surveys and explorations, occurrence and location of mineral and other deposits of value, surface and subterranean water supply and power and mineral waters, and the best and most economical methods of development, together with analysis of soils, minerals and mineral waters, with maps, charts and drawings of same."

There has been no change or amendment to the foregoing, which sets forth that the purpose of the Survey is to obtain information on the occurrence of various mineral and other natural resources. Thus the law proposes a distinct economic aim in that such investigations should be of assistance in the development, conservation and utilization of the state's natural resources. The results of investigations shall be published annually and thus become available to those interested.

That the Survey also has an educational aim is seen from Section 4. This provides for "the collection of specimens illustrating the geological and mineral features of the state." Sets of these are to be deposited with each of the state colleges. Both through the printed reports and by collections of the mineral resources and geological specimens the Survey acts as an educational medium.

The plan of investigation, as outlined in the First Annual Report, has been maintained, namely, that of taking up some one resource and reporting on it rather than making incomplete reports on the varied resources. Those natural resources already reported upon are detailed in the following list of publications: Many of the whole reports are no longer available owing to exhaustion of supply. These are indicated by an asterisk (*). The separate papers making up the whole volume are, in many instances, still available. These are followed by the dagger sign (†).

First Annual Report, 1908, 114 pp., 6 pls.*

This report contains: (1) a sketch of the geology of Florida; (2) a chapter on mineral industries, including phosphate, kaolin or ball clay, brick-making clays,

fuller's earth, peat, lime, cement and road-making materials; (3) a bibliography of publications on Florida geology, with a review of the more important papers published previous to the organization of the present Geological Survey.

Second Annual Report, 1909, 299 pp., 19 pls., 5 text figures, one map.*

This report contains: (1) a preliminary report on the geology of Florida, with special reference to stratigraphy, including a topographic and geologic map of Florida, prepared in co-operation with the United States Geological Survey; (2) mineral industries; (3) the fuller's earth deposits of Gadsden county, with notes on similar deposits found elsewhere in the state.

Third Annual Report, 1910, 397 pp., 28 pls., 30 text figures.*

This report contains: (1) a preliminary paper on the Florida phosphate deposits; (2) some Florida lakes and lake basins; (3) the artesian water supply of eastern Florida; (4) a preliminary report on the Florida peat deposits.

Fourth Annual Report, 1912, 175 pp. 16 pls., 15 text figures, one map.

This report contains: (1) the soils and other surface residual materials of Florida, their origin, character and the formations from which derived†; (2) the water supply of west-central and west Florida; (3) the production of phosphate rock in Florida during 1910 and 1911.

Fifth Annual Report, 1913, 306 pp., 14 pls., 17 text figures, two maps.*

This report contains: (1) origin of the hard rock phosphates of Florida†; (2) list of elevations in Florida; (3) artesian water supply of eastern and southern Florida†; (4) production of phosphate in Florida during 1912; (5) statistics on public roads in Florida.

Sixth Annual Report, 1914, 451 pp., 90 figures, one map.*

This report contains: (1) mineral industries and resources of Florida†; (2) some Florida lakes and lake basins; (3) relation between the Dunnellon and Alachua formations; (4) geography and vegetation of northern Florida†.

Seventh Annual Report, 1915, 342 pp., 80 figures, four maps.*

This report contains: (1) pebble phosphates of Florida†; (2) natural resources of an area in Central Florida; (3) soil survey of Bradford county†; (4) soil survey of Pinellas county†.

Eighth Annual Report, 1916, 168 pp., 31 pls., 14 text figures.*

This report contains: (1) mineral industries; (2) vertebrate fossils, including fossil human remains†.

Ninth Annual Report, 1917, 151 pp., 8 pls., 13 figures, two maps.

This report contains: (1) mineral industries; (2) additional studies in the Pleistocene at Vero, Florida†; (3) geology between the Ocklocknee and Aucilla rivers in Florida†.

Tenth and Eleventh Annual Reports, 1918, 130 pp., 4 pls., 9 figures, two maps.*

This report contains: (1) geology between the Apalachicola and Ocklocknee rivers; (2) the skull of a Pleistocene tapir with description of a new species and a note on the associated fauna and flora; (3) geology between the Choctawhatchee and Apalachicola rivers; (4) mineral statistics; (5) molluscan fauna from the marls near DeLand.

Twelfth Annual Report, 1919, 153 pp., four maps.*

This report contains: (1) literature relating to human remains and artifacts at Vero, Florida†; (2) fossil beetles from Vero†; (3) elevations in Florida†; (4) geologic section across the Everglades of Florida†; (5) the age of the underlying rocks of Florida as shown by the foraminifera of well borings; (6) review of the geology of Florida with special reference to structural conditions†.

Thirteenth Annual Report, 1921.

This report contains: (1) Oil prospecting in Florida; (2) statistics of mineral production, 1918; (3) foraminifera from deep wells†; (4) geography of central Florida†.

Fourteenth Annual Report (this volume), 1922.

Bulletin No. 1. The Underground Water Supply of Central Florida, 1908, 103 pp., 6 pls., 6 text figures.*

This bulletin contains: (1) underground water, general discussion; (2) the underground water of central Florida, deep and shallow wells, spring and artesian prospects; (3) effects of underground solution, cavities, sinkholes, disappearing streams and solution basins; (4) drainage of lakes, ponds and swamp lands and disposal of sewage by bored wells; (5) water analyses and tables giving general water resources, public water supplies, spring and well records.

Bulletin No. 2. Roads and Road Materials of Florida, 1911, 31 pp., 4 pls.*

This bulletin contains: (1) an account of the road building materials of Florida; (2) a statistical table showing the amount of improved roads built by the counties of the state to the close of 1910.

In addition to the regular reports of the Survey as listed above, press bulletins have been issued as follows:

- No. 1. The Extinct Land Animals of Florida, February 6, 1913.
- No. 2. Production of Phosphate Rock in Florida during 1912, March 12, 1913.
- No. 3. Summary of Papers Presented by the State Geologist at the Atlanta Meeting of the American Association for the Advancement of Science, December 31, 1913.
- No. 4. The Utility of Well Records, January 15, 1914.
- No. 5. Production of Phosphate Rock in Florida during 1913, May 20, 1914.
- No. 6. The Value to Science of the Fossil Animal Remains Found Embedded in the Earth, January, 1915.

- No. 7. Report on Clay Tests for Paving Brick, April, 1915.
- No. 8. Phosphate Production for 1917, May 2, 1918.
- No. 9. Survey of Mineral Resources, May 10, 1918.
- No. 10. Phosphate Industry of Florida during 1918, June 5, 1919.
- No. 11. Statistics on Mineral Production in Florida during 1918, October 6, 1919.
- No. 12. Phosphate Industry of Florida during 1920, May 9, 1921.

The foregoing list of publications justifies the statement that the Survey has been active. Much has been done, and more could have been accomplished but for the limited appropriation which has hampered the work and the plans that have been formulated from time to time. Florida is a large state, and detailed investigations necessarily take time, so that if the work of reporting upon the state's natural resources has apparently made slow progress, it is for the reason just stated. Provision should be made for additional assistance on the Survey staff, and an increase of the fund for the maintenance of the Department should be provided. This would make the work more effective and give an impetus to the investigations of the varied resources. The Survey has suffered very greatly during the past few years, and not the less so during the past year; and it has been most difficult to adjust the stipulated appropriation to the usual demands of maintenance. Inadequacy of compensation, too, is one of serious concern. These have been met only through sacrifice and loyalty to the work, but there is a limit to such devotion to the cause, and attention should be given the Department.

MUSEUM

Material illustrative of the mineral products of the state are on display in the Survey museum. At present there are three double cases which serve both the purpose of display and storage. The storage cases are full, and much of the contents could be displayed to advantage if additional cases for such purpose were available. The museum needs more cases and other accessories, not only for the display of material now on hand but to provide space for the display of collections that could be made if these could be placed on exhibition instead of being consigned to boxes in a storage room.

WORK IN PROGRESS

The investigations now in progress relate chiefly to a revision of a report on the underground waters of the state. The underground water

supply of central Florida was the subject of the first bulletin issued. This has long been out of stock. In succeeding annual reports this valuable natural resource has been reported upon for other portions of the state. To meet the constant demand for information on this subject for the several counties of Florida and the need for bringing up to date local details consequent to a growing state, it has been deemed advisable to revise the previous separate reports covering sections of Florida and to incorporate the matter in one volume.

WORK PROVIDED FOR.

For several years there has been an insistent demand for information on the clays of the state. With the gradually decreasing supply of timber and the increasing cost of lumber for construction has come the growing demand for the more permanent building materials. The fact must not be lost sight of, that Florida uses millions of brick also for the surfacing of streets and roads. If clays could be found that would make a satisfactory vitrified block, not only would it mean an immense saving in the item of freight alone but it would also mean the bringing of important new industries to the state.

The need for a testing laboratory in connection with the usual work of the Survey has been urged, and appropriation for such installation has been requested, but without result. During the past year, however, arrangements were made to have the clays of the state investigated by Professor Olin G. Bell, of Cornell University.

Field work for this report will be carried on during the summer of 1922, and samples of all commercially promising deposits will be taken and tests made in the laboratory of the university just mentioned. The results of this work will be made available as early as possible, and it is hoped that the investigations will be the means of bringing to light deposits of clay suitable for the manufacture of various products. Such investigations would assist in establishing new industrial enterprises and be of service to those already established.

CO-OPERATION WITH THE UNITED STATES GEOLOGICAL SURVEY

During the past year the Florida Survey continued its co-operation with the United States Geological Survey in the matter of collecting statistics on mineral production. By this means, duplication of work

incident to the collection, and to the making of such returns by the producers, is avoided; and the arrangement, in the main, has been found satisfactory. This method also brings about uniformity in the totals of the several industries, which might not be the case if the statistics were collected independently.

Co-operation with the United States Geological Survey could be carried on very advantageously to a greater extent. Subjects of real importance and worthy of consideration in this respect are topographic mapping and a report on the water powers of the state. To enter into this, however, requires an increase in available funds. A suggestion as to the advantage of such method is the fact that the Federal Survey will co-operate upon a basis of equal expenditure of funds.

CO-OPERATION WITH OTHER DEPARTMENTS

A few years ago, in co-operation with the United States Bureau of Soils, surveys were made of some of the counties of the state. Termination of this co-operation was forced through a lack of funds. There is a demand, however, for a continuation of the work. And the Bureau of Soils will bear one-half of the expense of such investigations.

Co-operation with certain of our own state departments would prove mutually advantageous. The large amount of limestone, marl and clays used in building many of the roads now under construction suggests the desirability of making detailed reports on these materials and indicates the possible usefulness of such information to the State Road Department. An investigation of the sands and gravels of the state would also be of importance to those having in charge the problem of road building in Florida.

The relation between the State Geological Survey and the State Department of Agriculture is shown by some of the reports that have been prepared by the former; for instance, one dealing with the origin of the soils of the state, and others describing the native timber growth, the vegetation in detail and its relation to the soils and to the geology of the several geographic regions. Reports have been prepared by members of the Geological Survey for use of the Department of Agriculture.

With the Florida State Board of Health the Geological Survey might co-operate. This is particularly apparent in the matter of an investigation of the underground water supplies of the state.

FUTURE INVESTIGATIONS AND PLANS

TOPOGRAPHIC MAPPING

In the prosecution of any detailed work, accurate maps are an essential. They form the basis for all investigations dealing with surveys of every character. This Department has consistently urged that the topographic mapping prosecuted by the United States Geological Survey *should* be encouraged and that the Florida Survey *should* have a specific appropriation for the purpose of entering into co-operation with the Federal Survey and assist in such mapping in Florida.

WATER POWERS

The Survey recognizes the importance of stream-flow records as well as other data relative to the water-power possibilities of our several streams. It is well known that the factor of prime consideration in the location of industrial enterprises is cheap power. In water-power development it is not expected that Florida will measure up to such other Southern states as have mountainous districts within their borders, but there are many smaller water-power sites that should be made use of. At the present time there are only three (not to mention the several small grist mill sites of West Florida particularly) developed water powers in the state, as follows: On the Hillsborough River, formerly used as the source of power for the city of Tampa, but is now used only as an auxiliary; on the Withlacoochee River, about ten miles below Dunnellon, which supplies power to the phosphate mines and to several of the larger towns in that region; lastly, the small water power recently developed in Jackson County. There are other sites that have been surveyed, and this work should be encouraged to every possible extent by having as much data available on the watersheds of our several streams, flow measurements, and such other detailed information as can be procured. It should be made possible for the Florida Survey to co-operate with the Water Resources Branch of the United States Geological Survey in preparing a report on this resource.

GEOGRAPHY AND VEGETATION OF THE STATE

The northern and central portions of the state have been treated in detail with respect to mapping the distribution of the vegetation and with respect to the geography. It is planned to carry this character of investigation to the southern portion of the state and, if found practicable, to combine the previous reports, making for the state, as a whole,

one volume relating to this subject. The reports so far published have served a very useful purpose and are a foundation for a solution of some of the forest problems of Florida and determining soil possibilities by means of vegetation. The Geological Survey has been active in disseminating information in regard to our native vegetation and has co-operated with those agencies in the state that are fostering the interests of a conservation of these resources.

LIMESTONES

Florida is a state having vast deposits of limestone. These are found exposed at the surface in many of our counties from the extreme southern end of the peninsula to western Florida. These deposits are not only of scientific interest but of great economic importance. Much is known of these deposits; but, as yet, no detailed report has been made. It is the purpose of the Survey to take up the study of these deposits, primarily economic, in the near future. With this study will also be included that of possible cement resources. Some deposits of limestone in the state, the Chattahoochee limestone typically exposed along the river of that name in western Gadsden County, were formerly used in the manufacture of natural cement.

SANDS

An investigation of the sands in a state in which they are so universally present as in Florida may at first thought seem inconsistent with good judgment. Such, however, is not the case, and this is a resource that merits careful investigation. Throughout the state are found deposits of pure white, siliceous sands that are, no doubt, adapted to the manufacture of various grades of glass. Sands used for building purposes are more widely distributed, and at certain localities are found excellent deposits of coarser sands and gravel that are particularly good in concrete work. From certain sands along our coast the rare earths, including ilmenite, zircon and rutile, are recovered. The possibility of locating deposits of moulding sands should not be overlooked. Sands and gravels of particularly good grade are being dredged from the Apalachicola River. These are used in concrete work of all descriptions. It was this material that was used as the aggregate in the concrete bridge now spanning the Apalachicola River.

RECOMMENDATIONS

VALUE OF CUTTINGS FROM WELLS

The Florida Geological Survey has through its published reports and correspondence, as well as by other means, emphasized the value of preserving samples of the drillings from wells in every section of the state, regardless of the purpose for which they were bored. This has been effective to a degree, for many have voluntarily saved such drillings and sent them for examination to the State Geologist. With the continued interest in the question whether Florida will be added to the list of oil-producing states, there comes the certainty that test wells, in addition to those completed and to others that are under construction, will be drilled. Some of the promoters have rendered most courteous and generous co-operation and have supplied the Survey with excellent sets of the drillings from their wells. In order, however, that the importance of such work be stressed it would be most advisable to have a statute requiring that samples from all wells drilled as tests for oil be taken at stated intervals. Many states have such a law which provides that samples be preserved and submitted to certain state officials whose duty it is to examine them, make such correlations as are possible and submit a descriptive log to the owners of the well. It is recommended that a law of this kind be made operative in Florida.

CONSERVATION OF THE UNDERGROUND WATER SUPPLY.

The necessity for guarding against the waste of artesian water has been stressed in previous reports of this Survey, particularly the Fifth Annual Report. The very apparent decrease in flow and volume of wells throughout the state during the past few years, which in some sections has caused special concern, but emphasizes the need for conservation of this natural resource and the wisdom of the recommendation, made in the report above referred to. It is urged that the law prohibiting the waste of artesian water there suggested be enacted.

ADDITIONAL FUNDS NEEDED

A department that has continuously served the state for a period of fifteen years might be regarded as having passed the probationary or experimental period and entitled to be ranked with the more or less per-

manently established state institutions. Since its organization in 1907, the Florida Geological Survey has functioned, without any change or amendment, under the law which created it. The total annual appropriation for its maintenance is \$7,500. Of this amount \$2,500 is specified as the salary of the State Geologist, and \$5,000 for the contingent expenses, which include the salary of any assistants, traveling expenses, field equipment, office and museum supplies, transportation charges on collections and other materials, printing of reports, engraving maps and halftones for illustrating reports, postage and all other expenditures incident to the work of the Department.

During these years, in which the appropriation has remained stationary, there have been decided upward trends in all commodities, the dollar today being worth only about one-half what it was in 1907, the year in which the Survey was established. With this monetary shrinkage have come greater demands upon the Survey for information on the state's resources. The work of the Department has grown, and, in order to render a service commensurate with the demands and the natural resource possibilities of the state, it is imperative that an increase be made in the amount now allotted, which has long been totally inadequate. I urgently suggest that this matter be given consideration, for it is vitally important to the future work of this Department. The appropriation should be at least twice the amount now available. With an annual allotment of \$15,000 the Survey could more effectively assist in the development of the varied natural resources of the state.

EXPENDITURES OF THE GEOLOGICAL SURVEY FOR THE PERIOD FROM JULY 1, 1920, TO DECEMBER 31, 1921

The following list itemizes the warrants issued showing the expenditures of the Survey from July 1, 1920, to December 31, 1921. The total amount appropriated for the maintenance of the State Geological Survey is \$7,500 per annum. This amount was sufficient for the first few years of the Survey, but is wholly inadequate for the maintenance of an efficient department under present conditions. All accounts are approved by the Governor and are paid only by warrant drawn upon the State Treasurer by the Comptroller, no part of the fund being handled direct by the State Geologist. All original bills and itemized expense accounts are on file in the office of the Comptroller, duplicate copies being retained in the office of the State Geologist. The paid warrants are on file in the office of the State Treasurer.

LIST OF WARRANTS ISSUED FROM JULY 1, 1920, TO DECEMBER 31, 1921

JULY, 1920.

Herman Gunter, State Geologist, expenses for July.....	\$ 7.56
R. M. Harper, assistant, salary for July.....	175.00
Mrs. L. B. Robertson, stenographic services.....	100.00
George B. Perkins, office rent.....	41.66
Southern Telephone & Construction Co.....	3.50
Hill's Book Store, typewriter paper.....	3.60
George I. Davis, postmaster, 2,000 stamped envelopes.....	43.44
H. & W. B. Drew Co., 10 sectional bookcases.....	84.00

AUGUST, 1920.

R. M. Harper, assistant, salary for August.....	175.00
Sam Cobb, services during August.....	12.50
Mrs. W. J. McElwain, special stenographic services.....	14.00
George B. Perkins, office rent.....	41.66
Southern Telephone & Construction Co.....	3.50
John Wiley & Sons, Inc., publications.....	3.00
T. J. Appleyard, stationery.....	7.25
D. R. Cox Furniture Co., bookcases.....	25.50

SEPTEMBER, 1920.

Herman Gunter, State Geologist, salary for quarter ending September 30, 1920.....	625.00
George B. Perkins, office rent.....	41.66
Southern Telephone & Construction Co.....	3.50

OCTOBER, 1920.

Herman Gunter, State Geologist, expenses October.....	39.60
E. H. Sellards, expenses October.....	95.50
E. H. Sellards, part payment for preparing oil report.....	400.00
Mrs. L. B. Robertson, stenographic services.....	16.60
Mrs. W. J. McElwain, stenographic services.....	6.00

Sam Cobb, services during October.....	5.00
Fred Collins, janitor services	5.00
George B. Perkins, office rent.....	41.66
Southern Telephone & Construction Co.....	3.50
Leon Electrical Supply Co., supplies.....	5.90
H. & W. B. Drew Co., supplies.....	10.74
Remington Typewriter Co., 1 coupon book, 12 ribbons.....	9.00
The Gulf Publishing Co., subscription "Oil Weekly".....	5.00
American Railway Express Co.	3.52
Western Union Telegraph Co.	2.22
W. C. Dixon, freight and drayage.....	3.48

NOVEMBER, 1920.

Herman Gunter, State Geologist, expenses November.....	74.53
R. M. Harper, assistant, salary for November 23-30.....	46.67
E. H. Sellards, expenses November.....	24.45
Mrs. L. B. Robertson, stenographic services.....	6.50
Fred Collins, janitor services	10.00
George B. Perkins, office rent.....	41.66
Southern Telephone & Construction Co.....	3.50
Hick's Drug Store, small bottles and corks.....	2.00
Tallahassee Variety Works, shelf on exhibit case.....	12.50
American Railway Express Co.	2.49

DECEMBER, 1920.

Herman Gunter, State Geologist, salary for quarter ending December 31, 1920	625.00
Herman Gunter, State Geologist, expenses December.....	129.81
R. M. Harper, assistant, salary for December.....	175.00
Sam Cobb, services during November and December.....	18.75
Fred Collins, janitor services	10.00
George B. Perkins, office rent.....	41.66
Southern Telephone & Construction Co.....	3.50
The Ora Neff Co., office supplies.....	3.14
Maurice Joyce Engraving Co., halftones.....	43.40
Maurice Joyce Engraving Co., halftones.....	107.93
W. C. Dixon, drayage	1.50
T. J. Appleyard, stationery and printing.....	24.50

JANUARY, 1921.

R. M. Harper, assistant, salary for January.....	175.00
Sam Cobb, services during January.....	5.85
Fred Collins, janitor services	10.00
George B. Perkins, office rent.....	41.66
Southern Telephone & Construction Co.....	3.50
W. C. Dixon, drayage	3.00
George I. Davis, postmaster, stamps.....	25.00
Wrigley Engraving & Electrotype Co., zinc etching blocks.....	6.41
American Peat Society, subscription	3.00
Economic Geology Publishing Co., subscription.....	4.00

FEBRUARY, 1921.

R. M. Harper, assistant, salary for February.....	175.00
Fred Collins, janitor services	10.00
George B. Perkins, office rent.....	41.66
Southern Telephone & Construction Co.....	3.50
American Journal of Science, subscription for January and February..	1.00

Charles T. Simpson, book "Lower Florida Wilds".....	3.50
American Railway Express Co.	4.86
T. J. Appleyard, 250 Columbia clasp envelopes.....	4.50

MARCH, 1921.

Herman Gunter, State Geologist, salary for quarter ending March 31, 1921	625.00
Herman Gunter, State Geologist, expenses March.....	7.49
R. M. Harper, assistant, salary for March.....	175.00
Mrs. L. B. Robertson, stenographic services.....	5.85
Sam Cobb, services during February and March.....	11.00
Fred Collins, janitor services	10.00
George B. Perkins, office rent.....	41.66
Southern Telephone & Construction Co.....	3.50
W. C. Dixon, freight and drayage.....	3.50
W. C. Dixon, freight and drayage Thirteenth Annual Report.....	31.81
E. G. Chesley, four sectional bookcases.....	34.00
T. J. Appleyard, stationery and cards.....	14.50
George I. Davis, postmaster, stamps and box rent.....	51.50
American Railway Express Co.	7.66
E. O. Painter Printing Co., Thirteenth Annual Report.....	1,762.07

APRIL, 1921.

Mrs. L. B. Robertson, stenographic services.....	5.20
Sam Cobb, services during April.....	3.00
Fred Collins, janitor services	10.00
George B. Perkins, office rent.....	41.66
Southern Telephone & Construction Co.....	3.50
E. Leitz, Inc., one pocket lens.....	6.74
George I. Davis, postmaster, stamps.....	50.00
T. J. Appleyard, envelopes and record sheets.....	15.80
American Railway Express Co.	5.28

MAY, 1921.

Sam Cobb, services during May.....	7.50
Fred Collins, janitor services	10.00
George B. Perkins, office rent.....	41.66
Southern Telephone & Construction Co.....	3.50
Charles Williams, one roll wrapping paper.....	6.60
University of Chicago Press, subscription.....	3.60

JUNE, 1921.

Herman Gunter, State Geologist, salary for quarter ending June 30, 1921	625.00
Fred Collins, janitor services	10.00
George B. Perkins, office rent	41.66
Southern Telephone & Construction Co.....	3.50
Commercial Fertilizer, subscription	2.00
T. J. Appleyard, 1,000 press bulletins.....	14.00
George I. Davis, postmaster, stamps and box rent.....	11.50

JULY, 1921.

E. H. Sellards, balance for preparation of oil report.....	800.00
Fred Collins, janitor services	10.00
George B. Perkins, office rent.....	41.66
Southern Telephone & Construction Co.....	3.50
Seaboard Air Line Railway, undercharge.....	6.83
Yaeger-Rhodes Hardware Co., supplies	1.85
T. J. Appleyard, stationery	4.50

AUGUST, 1921.

M. K. Cooke, assistant, salary August 15-31, inclusive.....	68.55
M. K. Cooke, assistant, expenses August.....	81.58
Fred Collins, janitor services	10.00
George B. Perkins, office rent.....	41.66
Southern Telephone & Construction Co.....	3.50
Middle Florida Ice Co., two coupon books.....	4.00

SEPTEMBER, 1921.

Herman Gunter, State Geologist, salary for quarter ending September 30, 1921	625.00
Herman Gunter, State Geologist, expenses September.....	72.32
Herman Gunter, State Geologist, automobile mileage.....	89.60
M. K. Cooke, assistant, salary September.....	125.00
M. K. Cooke, assistant, expenses September.....	91.18
M. K. Cooke, assistant, automobile mileage.....	42.00
Fred Collins, janitor services	10.00
George B. Perkins, office rent.....	41.66
Southern Telephone & Construction Co.....	3.50
Yaeger-Rhodes Hardware Co., supplies	2.50

OCTOBER, 1921.

Herman Gunter, State Geologist, expenses October.....	70.03
Herman Gunter, State Geologist, automobile mileage.....	53.44
M. K. Cooke, assistant, salary October.....	125.00
M. K. Cooke, assistant, expenses October.....	83.11
M. K. Cooke, assistant, automobile mileage.....	55.52
Fred Collins, janitor services	10.00
George B. Perkins, office rent.....	41.66
Southern Telephone & Construction Co.	3.50
H. & W. B. Drew Co., supplies.....	5.48
American Railway Express Co.	13.27
Fielder & Allen Co., supplies.....	28.15
Gulf Publishing Co., subscription "Oil Weekly".....	5.00

NOVEMBER, 1921.

M. K. Cooke, assistant, salary November.....	125.00
Sam Cobb, services during November.....	2.25
Fred Collins, janitor services	10.00
George B. Perkins, office rent.....	41.66
Southern Telephone & Construction Co.....	3.50
H. & W. B. Drew Co., supplies.....	2.10
Groover-Stewart Drug Co., supplies	7.29
The Letter Shop, multigraphed letters.....	3.25
American Railway Express Co.	2.09

DECEMBER, 1921.

Herman Gunter, State Geologist, salary for quarter ending December 31, 1921	625.00
Herman Gunter, State Geologist, expenses December.....	15.18
M. K. Cooke, assistant, salary December.....	125.00
M. K. Cooke, assistant, expenses December.....	9.40
M. K. Cooke, assistant, automobile mileage.....	16.16
Fred Collins, janitor services	10.00
George B. Perkins, office rent.....	41.66
Southern Telephone & Construction Co.....	3.50
W. C. Dixon, drayage	28.75
George I. Davis, postmaster, stamps and box rent.....	26.50
Capitol Stone Co., polishing limestone.....	3.50
American Peat Society, subscription	5.00

MINERAL PRODUCTION IN FLORIDA DURING 1919

Co-operation in the collection of mineral statistics for 1919 was continued with the United States Geological Survey. This being the year for the collection of statistics by the Bureau of Census, co-operative arrangements were entered into with that Bureau by the United States Geological Survey. This delayed somewhat the publication of the returns, but avoided much duplication of work and expense, assuring also more detailed statistics and unified results. The returns as published in a recent bulletin of the Fourteenth Census are here abstracted.

The census does not cover enterprises which were idle, that is, in which neither productive work nor development work was done during the entire year, nor the products of any enterprise valued at less than \$500. This partially accounts for the discrepancies between the totals of the Bureau of Census and those of the United States Geological Survey.

"Florida, which ranks twenty-first among the states in size (land area 54,861 square miles) and thirty-second in population (968,470 in 1920), ranked thirty-second in value of mineral products for 1919. The state also ranked thirty-second in the total number of persons engaged in the mining industries and in the average number of wage earners employed.

"The industries reported for 1919, ranked according to the value of products, were the mining or quarrying of phosphate rock, fuller's earth, clay, limestone, and rare metals (titanium and zirconium). The mining industries which can be shown without disclosure of individual operations are ranked by value of products in Table 2.

"Phosphate rock mining which is localized in nine central Gulf Coast and adjoining counties is the leading mineral industry in Florida. In this industry Florida outranks all other states. The value of products reported for the phosphate-rock industry in Florida in 1919 was \$6,678,888,* which was 74.4 per cent of the value of all mineral products of the state and 64.8 per cent of the value of products of the phosphate-rock industry in the United States in 1919 (\$10,300,198).

"The mining industry second in importance was fuller's earth, produced in Gadsden and Manatee Counties. In this industry also Florida

*Total value of phosphate production during 1919, as shown by returns from producers collected by the U. S. Geological Survey in co-operation with the Florida Geological Survey, was \$7,797,929.

led all other states in 1919, with a production valued at \$1,779,550, which was 19.8 per cent of the total value of mineral products for the state and 88.1 per cent of the value of all fuller's earth produced in the United States in 1919 (\$2,019,226).

"The other mining industries, clay, limestone, and the recovery of rare metals from beach sands, were unimportant.

"A small amount of development work on non-productive mining property was reported by one operator in Florida in 1919.

"The relatively large number of small enterprises as determined by the average number of wage earners employed is shown in Table 3. Of the total number of mining enterprises in 1919 in Florida, 72.3 per cent were in classes having less than 101 wage earners and such enterprises employed only 33.6 per cent of the total number of wage earners. On the other hand, enterprises employing more than 100 wage earners constituted 27.8 per cent of the total number of enterprises and employed 66.4 per cent of the total number of wage earners. These larger enterprises were all in the phosphate rock and fuller's earth industries.

"The statistics for wage earners given in Table 4, showing the changes in the number employed, month by month, reflect conditions prevailing in the industries during the census year.

"Table 5 presents for 1919 statistics in detail for the state as a whole and for each industry that can be shown without the disclosure of individual operations."

TABLE 1
Comparative Summary, Producing Enterprises, 1919 and 1909.

	Mining Industries.		Per cent of Increase. ¹
	1919	1909	
Number of enterprises	36	36	
Number of mines and quarries	55	96	
Persons engaged	3,694	5,761	—35.9
Proprietors and firm members, total	8	9	
Number performing manual labor in or about the mines and quarries	2		
Salaried employees	314	304	3.3
Wage earners (average number)	3,372	5,448	—38.1
Power used (horsepower)	44,969	42,366	6.1
Capital	\$58,067,662	\$20,794,901	179.2
Principal expenses:			
Salaries	666,202	495,759	34.4
Wages	3,107,813	2,350,854	32.2
Contract work	121,202	217,691	—44.3
Supplies and materials	1,836,229	738,946	148.5
Fuel and power	1,687,696	1,223,035	38.0
Royalties and rents	140,815	197,792	—28.8
Taxes	408,529	70,493	479.5
Value of products*	8,976,413	8,846,665	1.5

¹A minus sign (—) denotes decrease. Percentages are omitted where base is less than 100.

*Total mineral production of Florida in 1919, according to returns collected by the Florida Geological Survey in co-operation with the United States Geological Survey, was \$10,513,495. Total for 1909, according to U. S. Geological Survey was \$9,364,171.

TABLE 2
Principal Industries, Producing Enterprises, Ranked by Value of Products, 1919.

Industry.	Number of Enter- prises.	Wage Earners.		Value of Products.	
		Average Number.	Per cent of Total	Amount.	Per cent of Total
All industries	36	3,372	100.0	\$8,976,413	100.0
Phosphate rock	23	2,330	69.1	\$6,678,888	74.4
Fuller's earth	5	717	21.3	\$1,779,550	19.8
Limestone	4	111	3.3	177,201	2.0
All other industries ¹	4	214	6.3	340,774	3.8

¹Includes enterprises in industries as follows: Clay, 3; rare metals (titanium and zirconium), 1.

TABLE 3

Size of Producing Enterprises, by Average Number of Wage Earners, for Selected Industries, 1919.

Industry and Wage Earners Per Enterprise.	Enterprises.		Wage Earners.	
	Number.	Per cent Distri- bution.	Number.	Per cent Distri- bution.
All industries	36	100.0	3,372	100.0
1 to 5	1	2.8	2	0.1
6 to 20	4	11.1	58	1.7
21 to 50	10	27.8	364	10.8
51 to 100	11	30.6	703	21.0
101 to 500	10	27.8	2,240	66.4
Phosphate rock	23	100.0	2,330	100.0
6 to 20	3	13.0	41	1.8
21 to 50	7	30.4	247	10.6
51 to 100	6	26.1	366	15.7
101 to 500	7	30.4	1,676	71.9
Fuller's earth	5	100.0	717	100.0
51 to 100	2	40.0	153	21.3
101 to 500	3	60.0	564	78.7
Limestone	4	100.0	111	100.0
1 to 5	1	25.0	2	1.8
6 to 20	1	25.0	17	15.3
21 to 50	1	25.0	40	36.0
51 to 100	1	25.0	52	46.8

TABLE 4

Wage Earners, by Months, for Selected Industries, 1919.

The month of maximum employment for each industry is indicated by italic figures and that of minimum by an asterisk (*).

Industry.	Average num- ber em- ployed During Year.	Number Employed on 15th Day of the Month or Nearest Representative Day.					
		Jan.	Feb.	March	April	May	June
All industries	3,372	3,848	3,903	3,861	3,934	2,202	*1,836
Phosphate rock	2,330	2,867	2,937	2,852	2,955	1,179	*814
Fuller's earth	717	602	*600	621	663	720	716
Limestone	111	110	108	<i>122</i>	119	<i>122</i>	113
All other industries	214	<i>269</i>	258	266	197	*181	193
		July	Aug.	Sept.	Oct.	Nov.	Dec.
All industries		2,330	2,745	2,961	3,650	4,282	<i>4,912</i>
Phosphate rock		1,277	1,649	1,870	2,553	3,190	<i>3,817</i>
Fuller's earth		748	795	799	779	778	783
Limestone		108	106	*102	105	115	*102
All other industries		197	195	190	213	199	210

TABLE 5

MISCELLANEOUS STATISTICS OF MINES AND QUARRIES IN FLORIDA, 1919

	Phos- phate rock	Ful- ler's earth	Lime- stone	Others	Total
Number of mines and quarries.....	40	5	6	4	55
(Thousands of dollars.)					
Capital invested	55,740	1,382	116.4	828.3	58,067
Principal expenses:					
Salaries and wages.....	2,922	534	96.7	220.8	3,774
Salaried officers	174	23	3.6	24.8	225
Superintendents and managers.....	170	25	9.8	9.0	214
Technical employees	76	4	0	0	80
Clerks, etc.	131	6	1.7	8.7	147
Laborers	2,372	476	81.7	178.3	3,108
Supplies and materials.....	1,455	279	34.4	67.2	1,836
Fuel	1,278	267	9.9	59.0	1,613
Power	70	0	4.4	0	74
Royalties and rents	129	5	5.6	1.5	141
Taxes	275	117	0.7	15.8	409
Contract work	115	6	0	0	121
Value of products	6,679	1,780	177.2	340.8	8,976
Persons engaged (total).....	2,585	748	124	237	3,694
Firm members, etc.	5	0	3	0	8
Salaried officers	27	6	3	8	44
Superintendents and managers.....	65	16	5	5	91
Technical employees	52	2	0	0	54
Clerks, etc.	106	7	2	10	125
Laborers (average number)	2,330	717	111	214	3,372
Average annual earnings (dollars):					
Officers	6,450	3,835	1,200	3,094	5,115
Superintendents and managers.....	2,610	1,595	1,953	1,802	2,345
Technical employees	1,463	2,100			1,490
Clerks, etc.	1,230	858	835	873	1,178
Laborers	1,018	664	736	835	923
Land controlled (acres).....	188,002	4,518	236	4,629	197,385
Mineral land operated (acres).....	108,925	4,260	236	4,629	118,050
Aggregate horsepower used.....	40,996	1,880	490	1,603	44,969
Fuel used:					
Hard coal (long tons).....	0	100	0	0	100
Soft coal (short tons).....	19,621	8,592	390	4,085	32,688
Coke (short tons)	146	0	0	0	146
Wood (cords)	32,022	9,630	2,052	863	44,567
Fuel oils (barrels)	657,039	79,392	0	51,000	787,431
Gasoline, etc. (barrels).....	10,786	712	0	112	11,610

STATISTICS ON MINERAL PRODUCTION IN FLORIDA DURING 1920

COLLECTED IN CO-OPERATION BETWEEN THE FLORIDA GEOLOGICAL SURVEY
AND THE U. S. GEOLOGICAL SURVEY

The total value of the mineral production in Florida during 1920, as shown by returns made by the producers, was \$23,435,804. This represents an increase of \$12,922,309 over that of 1919. This remarkable increase is due largely to the enormous activity of the phosphate industry, the increase in the value of phosphate alone amounting to \$11,666,433. Most of the other industries show an increase, although some show a decrease.

BALL CLAY OR PLASTIC KAOLIN

The ball clays of Florida are white burning, refractory clays of high plasticity. The clay is commercially produced in only two counties, but is distributed quite generally through the central peninsular portion of the state. The manner of occurrence is in association with a rather coarse sand and quartz pebbles, from which it is separated by washing. During 1920 there were three companies mining ball clay in the state. These were: The Edgar Plastic Kaolin Company, Edgar, Putnam County; the Immaculate Kaolin Company, Controller, and the Lake County Clay Company, both located near Okahumpka, Lake County. The figures on the value of production are not given separately, but are included in the total mineral production of the state. There was a considerable increase in quantity and value of the 1920 production over that of the year 1919.

BRICK AND TILE

The conditions prevailing during 1919 were unfavorable to the brick and tile industry, due to the high cost of labor, high transportation and also to the high cost of building materials which curtailed construction. While some of the conditions were more favorable during 1920, the high transportation charges remained. There was a considerable increase, however, in the production of common brick. The total number of common brick manufactured in Florida during 1920 was 21,199 thousand, valued at \$312,150. This is a decided increase over the 1919 production, which was 16,067 thousand, valued at \$185,135.

The following firms reported the production of common brick during 1920:

Barrineau Bros., Quintette, Escambia County.
Callahan Brick Co., Callahan, Nassau County.
Campville Brick Co., Campville, Alachua County.
Clay County Steam Brick Co., Green Cove Springs.
E. M. Davis, Ocklocknee, Gadsden County.
Dolores Brick Co., Molino, Escambia County.
Florida Industrial School for Boys, Marianna, Jackson County.
Gamble and Stockton Co., Jacksonville, Duval County.
Glendale Brick Works, Glendale, Walton County.
Guilford Brick Co., Blountstown, Calhoun County.
W. J. Hall & Son, Chipley, Washington County.
Keystone Brick Co., Whitney, Lake County.
Tallahassee Pressed Brick Co., Havana, Gadsden County.
Whitney Brick & Manufacturing Co., Whitney, Lake County.

FULLER'S EARTH

The activity in the fuller's earth industry during 1920 was much greater than that of the preceding year, which was the most active year of the industry up to that time. There was a marked increase, both in the quantity of the earth mined and in the value. Florida has been the chief producer of fuller's earth since the beginning of the industry, being credited with 85 per cent of the production of the United States for the year 1920. The use of the Florida earth is principally in clarifying mineral oils, although its use in clarifying vegetable oils is continuing. The value of production for 1920 is not given separately, but is included in the total mineral production.

The following companies are engaged in the mining of fuller's earth in Florida:

The Atlantic Refining Company, Ellenton, Manatee County.
The Floridin Company, Quincy and Jamieson, Gadsden County.
The Fuller's Earth Company, Midway, Gadsden County.
The Manatee Fuller's Earth Corporation, Ellenton, Manatee County.

ILMENITE

The production of ilmenite and other rare earths from the beach sands near Pablo Beach, Duval County, which was begun in 1916 and which was active in 1919, was not continued in 1920. Buckman & Pritchard, Inc., are pioneers in this industry in Florida and deserve much credit for the work already accomplished.

LIMESTONE

The total amount of limestone produced in Florida for quicklime, building, road-making, railroad ballast, and agricultural purposes, and also including the flint rock associated with it, during the year 1920 was 349,524 tons, valued at \$569,097.

The following companies reported the production of limestone, lime or flint for the year 1920:

Blowers Lime and Phosphate Co., Ocala.
Commercial Lime Co., Ocala and Reddick.
Crystal River Rock Co., Leesburg and Crystal River.
Florida Lime Co., Ocala.
E. P. Maule, Ojus and West Palm Beach.
Oakhurst Lime Co., Ocala.
Ojus Rock Co., Ojus.
State of Florida (State Road Department).
A. T. Thomas Co., Ocala.

PEAT

Production of peat in Florida was reported by the Alphano Humus Company. The location of the plant was at Meadows, Marion County. The peat produced was put on the market in the form of prepared humus and was largely used as a fertilizer filler. The plant has not operated since August, 1920. The amount of production for the year 1920 is not listed separately, but is included with the total for the state.

PHOSPHATE

The following statement regarding the production of phosphate in Florida during 1920 was issued by the State Geological Survey, May 9, 1921:*

"The phosphate industry of Florida in 1920 far exceeded that of any previous year, both in point of production and of value. This fact is brought out by statistics collected in co-operation with the United States Geological Survey and recently tabulated. The total shipment of phosphate from Florida during 1920 was 3,369,384 long tons, as compared with 1,660,200 long tons in 1919. This is an increase of 1,709,184 tons, which is more than twice the production for the previous year. The year 1913 is referred to as the "peak" year of the phosphate industry

*The Phosphate Industry of Florida During 1920, by Herman Gunter, Fla. State Geol. Survey, Press Bulletin No. 12, May 9, 1921.

of the state, production that year amounting to 2,545,276 long tons, with a valuation of \$9,563,084. It is thus seen the output record for 1920 exceeds the former one by 824,108 tons and in value by \$9,901,278. The quantity of phosphate rock mined and marketed during 1920 from the whole United States was 4,103,982 long tons. Of this amount, from the figures above given, it will be seen that Florida produced 82 per cent.

"The following table gives the production and value of the three varieties of phosphate rock produced in Florida for the years 1919 and 1920:

Variety	1919		
	Quantity (Long Tons)	Value	Average Value Per Ton
Hard rock	285,467	\$2,452,563	\$ 8.59
Soft rock	14,498	196,318	13.54
Land pebble	1,360,235	5,149,048	3.79
	1,660,200	\$7,797,929	\$ 4.70

Variety	1920		
	Quantity (Long Tons)	Value	Average Value Per Ton
Hard rock	400,249	\$4,525,191	\$11.31
Soft rock	13,953	190,551	13.66
Land pebble	2,955,182	14,748,620	4.99
	3,369,384	\$19,464,362	\$ 5.78

"The recovery of the industry from the depressing conditions attributable to the recent world war is shown both in the largely increased production from the pebble phosphate fields and the very decided increase from the hard rock fields, as compared with the output for several preceding years. The amount of hard rock phosphate marketed during 1920 is evidence of the increased demand for this high-grade rock. Soft phosphate maintained the record set in 1919, practically the same quantity being marketed in 1920 as in that year.

"The most striking increase in production for the year was from the pebble phosphate field, where the amount marketed totaled 1,594,947 tons more than in 1919. The average value per ton for the pebble rock

increased from \$3.79 in 1919 to \$4.99 in 1920. The hard rock production increased 114,782 tons. The average value of this variety increased from \$8.59 per ton in 1919 to \$11.31 in 1920. For soft phosphate there was a slight decrease in the amount marketed, the average value per ton remaining practically the same in 1920 as in 1919.

"The total production of phosphate rock in Florida since the beginning of the industry in 1888 to the close of 1920, according to statistics collected by the Florida Geological Survey and the United States Geological Survey, is estimated to be 40,239,898 tons, with a total valuation of \$156,318,078."

LIST OF PHOSPHATE MINING COMPANIES OF FLORIDA, 1920

Acme Phosphate Co.	Morrison, Fla.
Alachua Phosphate Co.	Gainesville, Fla.
American Agricultural Chemical Co.	2 Rector St., New York, N. Y., and Pierce, Fla.
American Cyanamid Co.	511 Fifth Ave., New York, N. Y., and Brewster, Fla.
American Hard Rock Phosphate Co.	Floral City, Fla.
Armour Fertilizer Works	209 W. Jackson Blvd., Chicago, Ill., and Bartow, Fla.
P. Basset.	Newberry, Fla.
Peter B. & Robert S. Bradley.	92 State St., Boston, Mass., and Floral City, Fla.
J. Buttgenbach & Co.	22 Ave. Marnix, Brussels, Belgium, and Dunnellon, Fla.
C. & J. Camp.	Ocala, Fla.
Charleston, S. C., Mining & Manufacturing Co.	Richmond, Va., and Ft. Meade, Fla.
Coronet Phosphate Co.	99 John St., New York, N. Y., and Plant City, Fla.
Cummer Lumber Co.	453 St. James Bldg., Jacksonville, Fla., and Newberry, Fla.
Dunnellon Phosphate Co.	106 E. Bay St., Savannah, Ga., and Rockwell, Fla.
Florida Phosphate Mining Corporation.	P. O. Box 1118, Norfolk, Va. and Bartow, Fla.
Florida Soft Phosphate & Lime Co.	Ocala and Citra, Fla.
Franklin Phosphate Co. (P. J. & J. H. Norfleet, Lessees)	Newberry, Fla.
Holder Phosphate Co.	3353 Jefferson Ave., Cincinnati, Ohio, and Inverness, Fla.
Independent Chemical Co.	33 Pine St., New York, N. Y., and Mulberry, Fla.
International Agricultural Corporation.	61 Broadway, New York, N. Y., and Mulberry, Fla.
Mutual Mining Co.	102 E. Bay St., Savannah, Ga., and Floral City, Fla.
Morris Fertilizer Co.	801 Citizens & Southern Bank Bldg., Atlanta, Ga., and Bartow, Fla.
Norfleet & Williams (Downing Phosphate Co., Lessees)	Newberry, Fla.

Otis Phosphate Co. (P. J., J. H. and F. C. Norfleet, Lessees).....	Benotis, Fla.
Palmetto Phosphate Co.	2 Rector St., New York, N. Y., and Tiger Bay, Fla.
Phosphate Mining Co.	55 John St., New York, N. Y., and Nichols, Fla.
L. N. Pipkin	Mulberry, Fla.
Seminole Phosphate Co.	Croom, Fla.
Societe Universelles de Mines, Indus- trie, Commerce et Agriculture.....	Pembroke, Fla.
Southern Phosphate Development Co..	Inverness, Fla.
Southern Phosphate Corporation.....	25 Broad St., New York, N. Y., and Lakeland, Fla.
Swift & Co.	Union Stock Yards, Chicago, Ill., and Bartow, Fla.
T. A. Thompson	Ft. White, Fla.

SAND AND GRAVEL

The sand produced in Florida is used principally for building, paving and road-making, filtering, molding, cutting, grinding and blast purposes. The gravel produced is reported as used for roofing material and for railroad ballast. Deposits of clayey sand and gravel occurring in the southern part of Jackson County have been quarried and used for road-surfacing materials. The production of sand and gravel for the year 1920 was 132,749 short tons, valued at \$117,601.

The companies reporting the production are as follows:

Crystal River Rock Company, Crystal River.
Interlachen Sand and Gravel Company, Interlachen.
Lake Weir Washed Sand Company, Lake Weir.
Tallahassee Pressed Brick Company, Havana.
Tampa Sand and Shell Company, Tampa.

SAND-LIME BRICK

The materials used in the manufacture of sand-lime brick are sand and lime. The bonding power of the brick is due to the chemical reaction between these ingredients. The chemical changes occur in the presence of heat, pressure and moisture, and result in the formation of hydro-silicates of calcium and magnesium.

The sand used in the manufacture of sand-lime brick should be comparatively pure, with some variation in the size of the grains. The mixture of sand, lime and water is cut into the form of bricks and conveyed to a hardening cylinder and subjected to a temperature and pressure which vary according to the method of treatment.

Two companies were actively engaged in the manufacture of sand-lime brick in Florida during 1920, the Bond Sandstone Brick Company, Lake Helen, and the Plant City Composite Brick Company, Plant City. The production is included with the total mineral production of the state.

WATER

The total sales of mineral water in Florida during 1920, as shown by returns from the owners of the wells and springs, show a slight increase in quantity of production and a great increase in value. There were only three producers that made returns, so the amount and value cannot be disclosed.

The following companies reported the sale of mineral water for 1920:

Espiritu Santo Springs, Safety Harbor.
Good Hope Water Company, Jacksonville.
Purity Springs Water Company, Tampa.

SUMMARY

Common or building brick, fireproofing brick, tile and drainage tile.....	\$ 312,150
Lime and limestone, including lime and ground limestone for agricultural use, and crushed rock for railroad ballast, concrete and road material	569,097
Sand and gravel	117,601
Phosphate rock	19,464,362
Mineral products not separately listed, including ball clay, fuller's earth, pottery products, sand-lime brick, mineral waters and peat.....	2,972,594
Total mineral production during 1920 valued at.....	\$23,435,804

ON THE PETROLEUM POSSIBILITIES OF FLORIDA

(WITH FIGURES 1-10 AND GEOLOGIC MAP)

E. H. SELLARDS AND HERMAN GUNTER

TABLE OF CONTENTS.

	PAGE
Introduction	39
Oil tests in Florida	39
Literature	41
Acknowledgments	41
Composition and properties of oil and gas.....	42
Paraffin and asphalt base	43
Specific gravity	43
The origin of petroleum	44
The accumulation of oil and gas.....	45
Migration of oil	46
Storage of oil	46
Geologic structures favorable to accumulation.....	47
Inclined porous stratum	47
Folded strata	49
Anticlinal folds	49
Faults	50
Domes	51
Salt domes	51
Volcanic plugs	53
The depth of oil wells	53
Methods of drilling	54
Rotary	54
Cable	54
Diamond drill	54
Geologic distribution of oil and gas.....	56
Geologic time table	56
Surface indications of petroleum	57
The object of geologic investigations	58
Geologic formations in Florida	59
Lithologic characteristics and geographic distribution.....	60
Eocene	60
Ocala formation	60
Oligocene	61
Marianna formation	61
Chattahoochee formation	61
Tampa formation	62
Miocene	62
Alum Bluff formation	62
Jacksonville formation	63
Choctawhatchee formation	64
Pliocene	64
Pleistocene	64
Geologic map discussed	65
Structural features	67

CONTENTS—CONTINUED.

	PAGE
Table of Coastal Plain formations	71
Geologic subdivisions	69
West of the Suwannee River.....	70
Marianna-Chipley area	70
Pensacola area	73
Quincy area	75
Tallahassee area	77
Peninsular Florida	79
Live Oak area	79
Ocala area	80
Brooksville area	84
Jacksonville area	84
Daytona area	85
Kissimmee area	86
Tampa area	87
Fort Myers area	91
Miami area	92
Key West area	94
Discussion by counties.....	95
Alachua County	95
Baker County	96
Bay County	96
Bradford County	97
Brevard County	97
Broward County	98
Calhoun County	98
Charlotte County	100
Citrus County	100
Clay County	100
Columbia County	100
Dade County	101
DeSoto County	102
Dixie County	102
Duval County	102
Escambia County	103
Flagler County	103
Franklin County	103
Gadsden County	104
Glades County	105
Hamilton County	105
Hardee County	106
Hernando County	106
Highlands County	107

CONTENTS—CONTINUED.

	PAGE
Hillsboro County	107
Holmes County	108
Jackson County	108
Jefferson County	109
Lafayette County	109
Lake County	109
Lee County	110
Leon County	110
Levy County	111
Liberty County	111
Madison County	112
Manatee County	112
Marion County	113
Monroe County	114
Nassau County	114
Okaloosa County	115
Okeechobee County	115
Orange County	116
Osceola County	116
Palm Beach County	118
Pasco County	118
Pinellas County	118
Polk County	119
Putnam County	120
St. Johns County	120
St. Lucie County	120
Santa Rosa County	121
Sarasota County	122
Seminole County	122
Sumter County	123
Suwannee County	123
Taylor County	124
Union County	124
Volusia County	125
Wakulla County	125
Walton County	125
Washington County	127
General Considerations	128

ILLUSTRATIONS.

TEXT FIGURES.

	PAGE
Fig. 1—Outline map of Florida showing location of wells.....	38
Fig. 2—Illustrating occurrence of oil in an inclined porous stratum.....	48
Fig. 3—Diagram showing conditions in 'Midway-Sunset' field.....	49
Fig. 4—Accumulation of oil and gas in an anticline.....	50
Fig. 5—A fault affording conditions favorable to accumulation of oil.....	51
Fig. 6—Diagrammatic section through a salt dome.....	52
Fig. 7—Volcanic intrusion affording conditions favorable to oil accumulation..	53
Fig. 8—"Falling Water" sink four miles south of Chipley.....	55
Fig. 9—The Apalachicola River showing Alum Bluff.....	63
Fig. 10—Outline map of Florida showing subdivisions.....	68

MAP.

Geologic Map of Florida	In pocket
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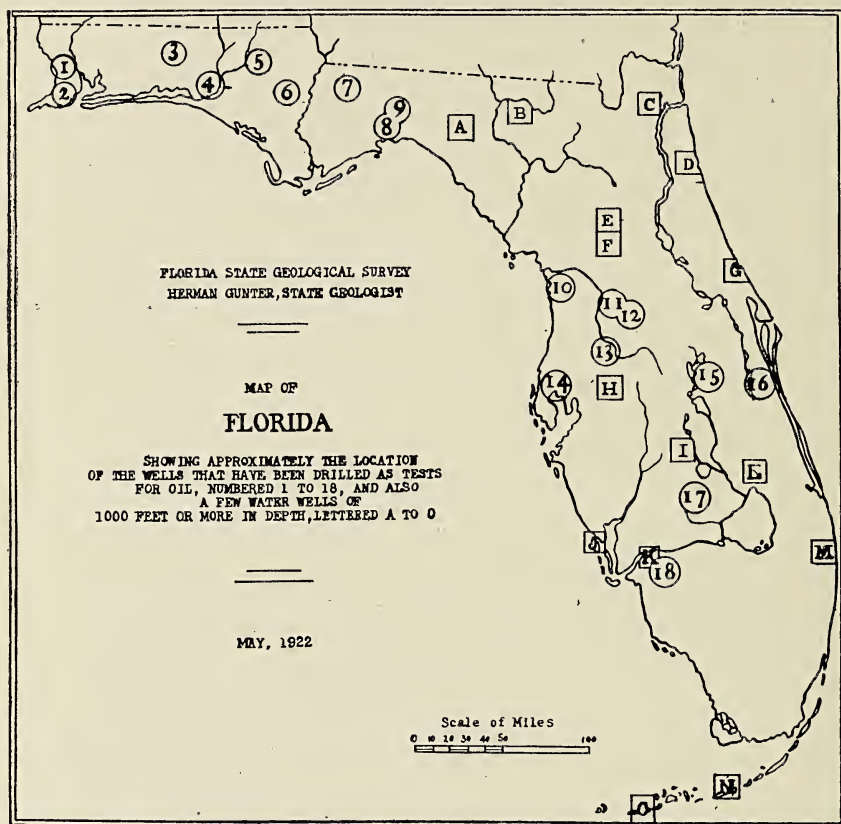


Fig. 1. Outline map of Florida showing location of wells as follows:

List of Test Wells for Oil.

No.	Location.	Depth.	No.	Location.	Depth
1	Near Cantonment	1452	10	Near Crystal River.....	1900
2	Near Pensacola, two wells. 1620 and 1702	1702	11	2½ miles south of Sumterville.....	3090
3	7 miles west of DeFuniak Springs..	1888	12	2½ miles south of Sumterville.....	2002
4	Near Bruce	770	13	4 miles east of Dade City.....	2200
5	4 miles south of Chipley	4912	14	Near Oldsmar, drilling.	
6	Near Clarksville	1320	15	10 miles south of Kissimmee.....	2000
7	Near Greensboro, about.....	1750	16	Near Melbourne, about	1000
8	Burns, two wells, one unfinished and one completed at.....	2169	17	Northeast of Palmdale, drilling.	
9	10 miles southeast of Tallahassee, drilling.		18	12 miles southeast of Ft. Myers, drilling.	

List of Water Wells.

No.	Location.	Depth.	No.	Location.	Depth.
A	Perry	1207	I	Sebring	1220
B	Live Oak	1080	J	Boca Grande	1812
C	Jacksonville	1180	K	Ft. Myers	1300
D	St. Augustine	1440	L	Okeechobee	1175
E	Citra	1200	M	Palm Beach	1207
F	Ocala	1250	N	Marathon	2555
G	New Smyrna	1440	O	Key West	2398½
H	Plant City	1100			

ON THE PETROLEUM POSSIBILITIES OF FLORIDA.

BY E. H. SELLARDS AND HERMAN GUNTER.

The widespread search for petroleum that is now in progress makes it certain that all states of the Union will in time be more or less tested with respect to their petroleum possibilities. In Florida a few test wells have already been drilled and others are sure to be drilled in the future. In view of these facts, this report has been prepared to give such information as is now available, both as to the character of rocks to be expected in drilling in Florida and as to structural conditions in the state.

So far as actual drilling is concerned, Florida has as yet been but little tested. Some of the tests made for oil of which record has been obtained are the following: In 1903 the Pearson Oil and Gas Company completed a test well for oil two and one-half miles south of Sumterville in Sumter County. This well reached a total depth of 2,002 feet and is reported to have given some shows of oil.* A well was subsequently drilled by this company in Citrus County, about two miles north of Crystal River, to a depth of about 1,900 feet. The Pensacola Development Company drilled two wells in Escambia County, one located five miles west of Pensacola and two miles north of the Navy Yard, the other located on East Hill, Pensacola. These are reported to be 1,620 and 1,702 feet deep, respectively.† Records indicate that no shows of oil were found. In 1905 the Southern States Lumber Company drilled a test well for oil about three miles west of Cantonment in Escambia County. This well reached a depth of 1,452 feet. No oil shows are reported. In 1914 the Kissimmee Oil Company attempted a test south of Kissimmee on S. 25, T. 26 S., R. 29 E. After much delay this well was finally drilled 2,000 feet or deeper. A log of this well will be found later in this report. (See Osceola County.) In 1916 the Bonheur Development Company began drilling near Burns in Wakulla County. Two wells have been drilled by this company, one of which reached a depth of 2,169 feet. Shows of oil were reported. (See Tallahassee Area.) The second well is not completed, but has a depth of about 2,000 feet. In 1917 the Flor-

*U. S. Geol. Surv., Bull. 298, p. 198, 1906.

†U. S. Geol. Surv., W. S. & Irr. Paper 102, pp. 246-247 and 258-259, 1904.

ida East Coast Oil, Gas and Mineral Co. began a test $3\frac{1}{2}$ miles south of Melbourne in Brevard County. This was drilled to a depth of about 1,000 feet, at which depth it was abandoned. Well No. 2 was started and has a depth of 115 feet. Near Greensboro, Gadsden County, a well was bored in 1917 which reached a depth of about 1,750 feet. Salt water is reported at about 1,300 feet. (See Gadsden County.) In 1918 the Dundee Petroleum Company completed a well a few miles south of Sumterville in Sumter County. This has a depth of 3,090 feet and is the deepest test so far drilled in peninsular Florida. A descriptive log of this well will be found later in this report. (See Ocala Area.) In 1918 a deep well was begun near the west bank of the Withlacoochee River, about five miles east of Dade City. This is reported to have a depth of 2,200 feet and to have flowed strong sulphur water at about 2,000 feet.* In October, 1919, the Calhoun Gas and Oil Company began their test near Clarksville, northern Calhoun County. This was abandoned in 1920 at the depth of 1,320 feet. Samples of the drillings were saved and a descriptive log will be found under notes on Calhoun County. During 1920 two wells were begun in Walton County, one about seven miles west of DeFuniak Springs at a locality known as Rat Head, and the other about twenty-five miles southeast of DeFuniak Springs, near Bruce. These tests have a reported depth of 1,888 feet and 770 feet, respectively. (For logs see Walton County.) During 1920 and 1921 a very careful test to 4,912 feet was made by the Chipley Oil Company about four miles south of Chipley, Washington County. This is the deepest well so far drilled in Florida.

A few tests are in progress at the present time, among which are: Central Florida Oil and Gas Company, about ten miles southeast of Tallahassee, Leon County, which was begun in March, 1921; the well by Mr. Rollin V. Hill, near Oldsmar, Pinellas County, begun November 24, 1921, and the test by the Florida Petroleum Syndicate, about twelve miles southeast of Ft. Myers, Lee County, which was begun March 30, 1922.

This report includes first an introductory statement as to the nature of petroleum and the conditions under which it occurs, followed by a discussion of the geology of Florida and of the conditions prevailing in

*From Mr. J. M. Critchlow, Lake Alfred, Florida, owner of the well. Conversation of February 15, 1922.

the several geologic provinces into which the state may be divided, together with additional notes arranged by counties. A geologic map has been prepared to accompany the report. In the concluding chapter of the report will be found a statement on the probabilities of oil and gas production in Florida.

LITERATURE

The literature available relating to the geology of Florida includes publications by the State Geological Survey of Florida, by the United States Geological Survey and by various scientific societies and journals. Among publications of the Florida Geological Survey which will be found serviceable in this connection may be mentioned the following: Second Annual Report, Stratigraphic Geology; Third and Fifth Annual Reports, water supply and well logs of eastern and southern Florida; Fourth Annual Report, water supply and well logs of west Florida; Ninth, Tenth, Eleventh and Twelfth Annual Reports, structural conditions and well logs; of the publications of the United States Geological Survey should be mentioned in particular the report on the geology and underground waters of Florida (Water Supply Paper No. 319), and several contributions in the series of Professional Papers. Many of the Tertiary invertebrates of Florida are described by W. H. Dall in Volume 3 of the Wagner Free Institute of Science; Publication No. 133 of the Carnegie Institution of Washington contains an important paper on the history of the Floridian Plateau by T. W. Vaughan. A bibliography of the publications on Florida geology will be found in the First and Twelfth Annual Reports of the Florida Geological Survey.

ACKNOWLEDGMENTS

Acknowledgments for co-operation with the Florida Geological Survey in the accumulation of data utilized in this report is due to practically all those who have made test borings for petroleum in Florida in recent years. Mention should be made in particular to E. C. Butler, Manager of the Chipley Oil Company; J. B. Wight, President of the Calhoun Gas and Oil Company; G. F. Kribbs, of the Kissimmee Oil Company; H. B. Goodrich, Geologist for the Dundee Petroleum Company; Bartlett G. Long, Consulting Geologist; J. L. Shepard, G. P. Billups and J. M. Critchlow.

In connection with the preparation of the geologic map, the United States Geological Survey contributed through the Director notes on the geology of west Florida made by C. Wythe Cooke. A part of the field work incorporated in this report was done in co-operation between the United States Geological Survey and the Florida Geological Survey in 1917.

As a convenience in reference, a number of well logs previously published have been copied into this report. These logs are from earlier reports of the Florida Survey and from the United States Geological Survey, and are in each instance credited to the source from which taken. The field work for this report was done jointly by the authors chiefly during the latter part of 1920. However, record of wells drilled since that time have been included, thus bringing the report up to the date of publication.

COMPOSITION AND PROPERTIES OF OIL AND GAS

The petroleum compounds, oil and gas, are natural products found within the earth, composed essentially of hydrogen and carbon. In addition to hydrogen and carbon, there may be present in oils a small amount of oxygen, nitrogen, or sulphur. The petroleum, as found in nature, although consisting of only two essential elements, are of extremely varied composition and have been shown by chemical analysis to form compounds which may be arranged in several series, and of each series there are many members. The more common petroleum compounds are those which are included in the paraffin, olefin and napthene series. Less common in nature are compounds of the acetylene and benzene, and several other series.

The petroleum compounds of the paraffin series, also known as the methane series, consist of hydrogen and carbon combined according to the following definite ratio: In all the compounds of this series there are two more than twice as many hydrogen atoms as there are carbon atoms. Members of this series, accordingly, include compounds expressed by the general formula: $C_nH(2n+2)$, in which "n" is the number of carbon atoms. In the case of a compound having six carbon atoms, the formula thus would be $C_6H(2 \times 6 + 2)$ or C_6H_{14} .

Marsh gas, or methane, is a gas of the paraffin series of compounds, for which the formula is CH_4 . Another gas of this series, ethane, has the formula C_2H_6 .

In the following table is given the name and formula of the common gases and oils of the paraffin series. The first four of these under ordinary conditions are gases, while the remainder are oils:

<i>Name</i>		<i>Formula</i>
Methane	gas	CH_4
Ethane	"	C_2H_6
Propane	"	C_3H_8
Butane	"	C_4H_{10}
Pentane	oil	C_5H_{12}
Hexane	"	C_6H_{14}
Septane	"	C_7H_{16}
Octane	"	C_8H_{18}
Nonane	"	C_9H_{20}
Decane	"	$\text{C}_{10}\text{H}_{22}$

In the olefin series there are in all cases twice as many hydrogen atoms as there are carbon atoms. The general formula for this series would therefore be C_nH_{2n} . As in the formula previously given "n" stands for the number of carbon atoms.

Other petroleum series that have been recognized in nature include those expressed by the following formulas: $\text{C}_n\text{H}_{2n-4}$, $\text{C}_n\text{H}_{2n-6}$, $\text{C}_n\text{H}_{2n-8}$, $\text{C}_n\text{H}_{2n-10}$, $\text{C}_n\text{H}_{2n-12}$. Each of these series may consist of many members.

PARAFFIN BASE AND ASPHALT BASE

Certain of the petroleum oils, particularly those of the paraffin series, upon evaporation leave a paraffin residue. Other petroleum oils, including those of the olefin and naphthene series, upon evaporation leave an asphaltic residue. Accordingly in commerce, petroleums are commonly known under these two main divisions, namely: those having a paraffin base and those having an asphalt base. The asphalt in oils is said to be due to the inclusion of oxygen or sulphur¹ in the compound. The petroleums with a paraffin base are of more value for refining purposes than are those having an asphalt base. Hence, the classification of oils as of paraffin and asphalt base is of commercial value.

SPECIFIC GRAVITY

The specific gravity affords an important aid in judging the quality and value of oil for refining purposes, the lighter oils being as a rule more valuable than the heavy oils. Since the oils are lighter than water,

¹Johnson and Huntley, Principles of Oil Production, p. 1.

the actual specific gravity expressed in the ordinary way is less than one. However, in ordinary usage a special scale has been devised known as the Baume scale, in which the gravity is expressed as whole numbers. On the Baume scale distilled water at 60° F. has a gravity marked as 10°, and the figures on this scale are so arranged that they increase as the gravity of the fluid decreases. Thus a heavy oil, but little lighter than water, may read 12° to 15° B., while a lighter oil may be found to read, say, 35° to 40° B. The gravity changes somewhat with temperature, and in practice the gravity is commonly given as at 60° F. If taken at a temperature other than 60° F., it may be reduced to the 60° equivalent.

Paraffin base oils are usually light, and hence on the Baume scale have a higher reading than asphalt base oils. The color of crude oils varies from light yellow, or straw color, to black. As a rule, oils of light color are likewise light in gravity. The odor varies decidedly, depending probably upon included gases. Hydrogen sulphide gas is often present in oils from limestones, giving a disagreeable odor. A terpene odor is occasionally detected, chiefly on light colored oils. Aromatic odors and an odor of gasoline characterize some of the crude oils.

Another property in which oils differ much among themselves is viscosity, or fluidity. As a rule, the light, or paraffin base oils, flow readily. Some of the heavy oils are so viscous as to require heating somewhat before they can be pumped through a pipe line.

THE ORIGIN OF PETROLEUM

The probable origin of petroleum in the earth has given rise to much discussion. It has been found by laboratory experiments that hydrocarbons may be obtained from organic substances and likewise from certain of the inorganic substances. From fish oil, hydrocarbons which are similar to those obtained from the petroleums have been obtained by destructive distillation. Wood and vegetable oils have likewise been shown to yield hydrocarbons. From cast iron, spiegeleisen and ferromanganese, when dissolved in a mineral acid, such as hydrochloric, there is evolved hydrogen and smaller quantities of hydrocarbons.¹ The hydrocarbons in these experiments are probably to be ascribed to the carbides contained in the iron. It is a matter of common knowledge also that most carbides react with water and form hydrocarbons.

¹A Treatise on Petroleum. Sir Boverton Redwood. Vol. I, Sec. 4, 1913.

The theories as to the origin of petroleum in nature that have been proposed may be divided into those that ascribe their origin to inorganic sources and those that recognize an organic source for petroleum. The inorganic theories are diverse, but those best known involve the assumption of the existence of carbides deep within the earth, from which hydrocarbons are formed.

The organic theories include those which ascribe the origin of petroleum to animal sources, those that ascribe the origin to vegetable sources, and those that ascribe the origin to vegetable and animal sources combined. The theory of origin from animal remains maintains that the petroleum originates from the slow decomposition of the fatty substances of animals imbedded in the rocks. Those who regard petroleum as derived from vegetable matter, for the most part name the lower plants as the probable source, including cellular marine plants, fucoids, seamuds, algae, and diatoms. Those who recognize that the petroleum oils may be derived in part from animal and in part from vegetable sources, are probably in majority at the present time.

The geologic relations of petroleum deposits undoubtedly support the organic theory of its origin. The diversity of petroleums and the varying kinds of sedimentary rock with which it is associated argues for the probable derivation, in some instances, from animal remains, and at other places from plant remains, or in other instances a combined origin from animals and plants imbedded, as they often are, in the same formation.

In the application of geology to the location of petroleum deposits, the organic theory of origin is very generally applied, and deposits high in organic matter are universally sought as one of the conditions favorable to the accumulation of oil in commercial quantities.

THE ACCUMULATION OF OIL AND GAS INTO DEPOSITS OF COMMERCIAL VALUE

In the preceding pages it has been stated that a probable source of oil and gas is in the organic matter, animal and plant, imbedded in the rocks. If such is true, there yet remains the problem of accounting for its accumulation in local deposits in sufficient amounts to be of commercial value. The organic materials in the rocks are widely disseminated,

while the oil as found in nature is usually segregated into relatively restricted areas.

MIGRATION OF OIL

It is a commonly accepted conclusion that oil and gas, as obtained commercially, have migrated more or less from the original source. The forces that influence migration include specific gravity, capillarity, and possibly some others not well understood. The well-known difference in specific gravity between oil, gas and water are probably among the important causes of separation of oil and gas. As oil is lighter than water, it naturally rises to the top, and hence tends to segregate in the rock above the water-line. Gas likewise accumulates at a level above the oil. In the case of strata inclined from the horizontal, and capped by an overlying impervious stratum, the oil and gas, for the same reasons, migrate up the dip to a level higher than the water.

The capillary attraction of liquids is a force that may be of importance in the migration of oil. The capillary attraction of oil is less than that of water. Hence, it is assumed that water, through capillary attraction, may force oil from rocks having small pores, such as shales, into rocks of larger pore space, such as sandstones.

It is probable that the compacting of sediments by its own weight is an important factor in compelling movement of included fluids. Other causes mentioned are increased temperature as sediments accumulate, affecting the fluidity of oil. A reduction in volume of voids in the rock in the course of time through cementation processes would likewise compel migration of included liquids and gases.¹

THE STORAGE OF OIL

The migration of oil in the rock will effect its segregation in commercial quantities only where the storage conditions are suitable. The rocks are capable of storing a gas or a liquid in proportion to their porosity, and any rock that is porous may under favorable conditions serve as a reservoir. As a rule, sands and sandstones are relatively high in porosity and much of the oil secured is taken from sands or sandstones. However, not all sands or sandstones are sufficiently porous to serve as important reservoirs. Nor is the same sandstone horizon as

¹Johnson and Huntley, *Oil and Gas Production*, p. 46.

a rule uniformly porous. Locally the pore space in the sandstone may be partly or wholly filled with a cementing substance, thus reducing or destroying the storage capacity of the rock. Limestones not infrequently store large quantities of oil either in the pore space incident to shell breccias or in solution cavities; dolomitic limestones are often notably porous rocks. On the other hand, shales which probably are the source of much of the oil have themselves but limited storage capacities, owing to the fine texture of the rock.

GEOLOGIC STRUCTURES FAVORABLE TO THE ACCUMULATION OF PETROLEUM

The migration of oil and gas under the influence of specific gravity, capillarity or otherwise, into porous rocks, is not of itself sufficient to bring about accumulation of oil in large quantities except in localities where the structural conditions in the rocks are favorable.

If a rock is uniform in porosity and horizontal in position, it may contain a considerable quantity of oil and gas and not afford favorable conditions for segregating either oil or gas in commercial quantities. In nature, however, it is rarely true that a rock formation is either entirely uniform in porosity or entirely horizontal in position. On the contrary, variation in porosity in the rocks and departure more or less pronounced from the horizontal in the rock stratum is the rule rather than the exception. Favorable geologic structures in this sense are those structural conditions in the rocks which bring about segregation of oil or gas in commercial quantities.

The conditions in the rock that may bring about storage of oil or gas are so varied as to be extremely difficult to classify or enumerate. It is not practicable to treat this phase of the subject exhaustively. However, a number of the best known structural conditions favorable to the accumulation of oil may be described.

AN INCLINED POROUS STRATUM

It has already been stated that rock formations rarely if ever lie entirely horizontal in the earth, and that inclination from the horizontal is a common condition. The effect of departure from the horizontal in a formation containing oil will be apparent. If the stratum contains both oil and water, the oil will be forced by the water up the dip. In such in-

clined strata there is no obvious trap by which to retain the petroleum and if the hydrostatic pressure is sufficient the oil may be forced to the surface and appear as an oil seep. On the other hand, reduction in porosity of the rock may limit the movement of the oil and form a trap by which it is retained at a definite level. In the case of an inclined stratum

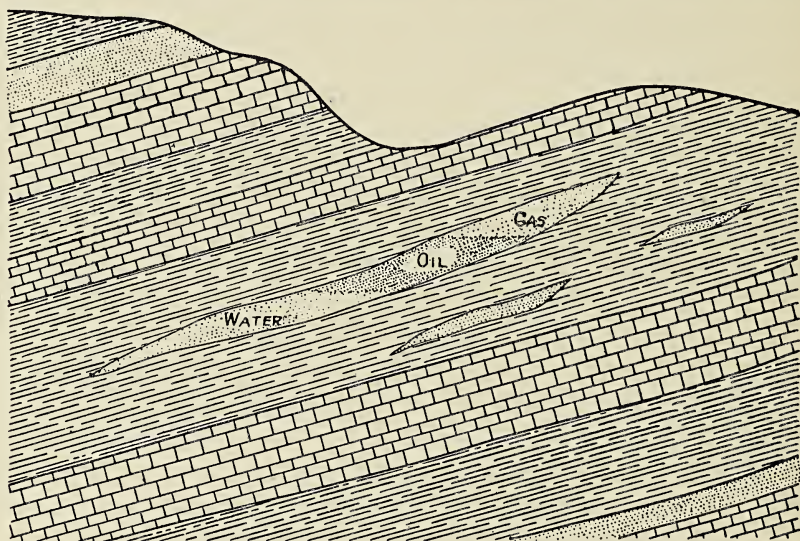


Fig 2. Illustrating conditions in which oil and gas may accumulate in sands in inclined strata.

of this kind, when the necessary variation in porosity to form a trap is lacking, the oil after exuding from the surface for a time as a seep may deposit heavy residue in the pores of the sand upon evaporation to such an extent as to cement the sand and thus form a trap for the retention of the remaining oil. Such a trap under much more complicated conditions has recently been described by Pack as occurring in the Sunset Field of California.* (Fig. 3.)

*U. S. Geol. Surv., Prof. Paper 116. The Sunset Midway Oil Field of California by R. W. Pack, 1920.

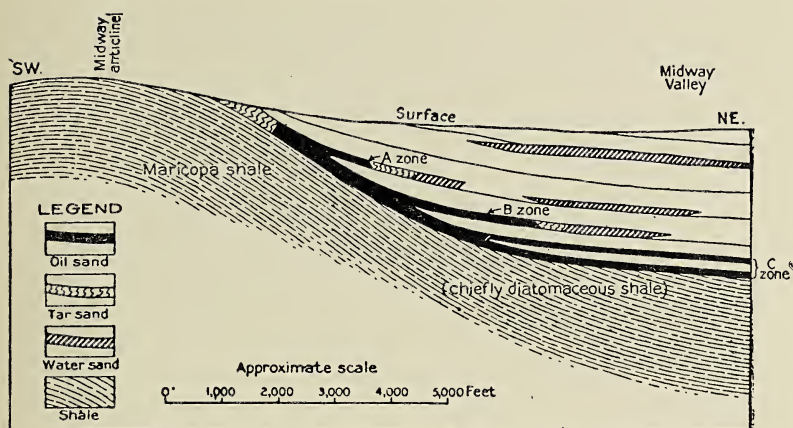


Fig. 3. Diagram showing the conditions found near Fellows in the Midway-Sunset Field of California. After Pack. The dark bands represent oil sands. Near the surface and also separating the oil from the water are accumulations of tar as indicated in the sketch.

FOLDED STRATA

Instead of being merely tilted, the rock strata may be folded in such a way as to form a trap to retain oil. A simple illustration would be a fold in otherwise horizontal strata such as is indicated by the accompanying sketch. (Fig. 4.) In this sketch the strata are bent up in such a way as to form a storage reservoir in the rock for oil and gas. In such a reservoir the gas is likely to be found near the axis, the oil next below the gas, and the water, if present, farther down the sides of the fold.

A simple symmetrical fold such as is represented in this sketch is rarely found in nature. More commonly the folding is more or less complicated.

ANTICLINAL FOLDS

A fold such as is represented in Figure 4 is known as an anticline, a term applied to folds that arch upwards. As a rule, in nature an upfold is more or less compensated by a corresponding downfold. To the downfold there is applied the term syncline. Of the different strata of the formations as shown in this illustration, one is represented as a porous horizon into which oil and gas enter from below or above and migrate up the dip. However, upon reaching the anticline both the gas

and the oil may be trapped and gradually accumulate until the anticlinal fold is filled, provided there is sufficient oil and gas to fill it. Obviously if the stratum contains water as well as oil, the water will accumulate in the synclines. If, however, the stratum contains but little or no water, there may be an accumulation of oil in the synclines.

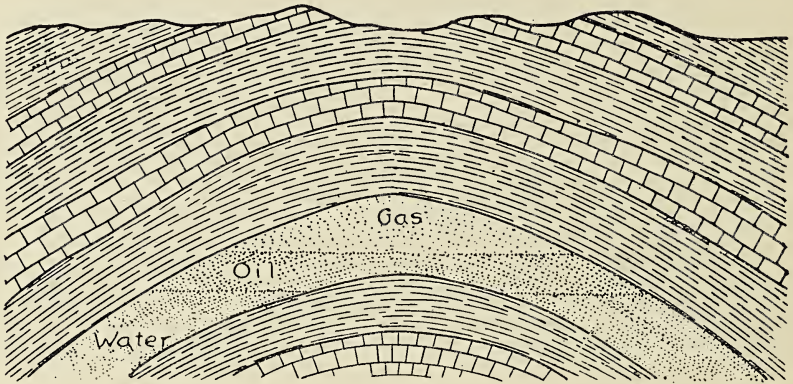


Fig. 4. Diagram representing an anticline affording conditions favorable to the accumulation of oil and gas.

Folds in the rocks, both anticlines and synclines, may be either symmetrical in form or lacking in symmetry, that is, unsymmetrical. In Figure 4 the fold is represented as symmetrical or essentially so. Unsymmetrical folds are more common in the earth than symmetrical ones. The nature of the fold, whether symmetrical or unsymmetrical, must be taken into account when locating a well.

The folds in a formation may extend in the direction of the dip or across the dip. If an anticlinal fold extends in the direction of the dip there is produced a type of structure known as a plunging anticline, by which is meant an anticline, the axis of which departs from the horizontal. If followed down the axis any given horizon in a plunging anticline will be found at successively lower levels.

FAULTS

Not infrequently a fault in rock brings about conditions favorable to the accumulation and storage of oil. Such a condition is illustrated in

the accompanying sketch. (Fig 5.) A porous stratum through which oil and gas may migrate as shown in this sketch is caused by faulting to terminate abruptly against an impervious stratum. Under these conditions oil and gas may accumulate in the porous stratum adjacent to the fault.

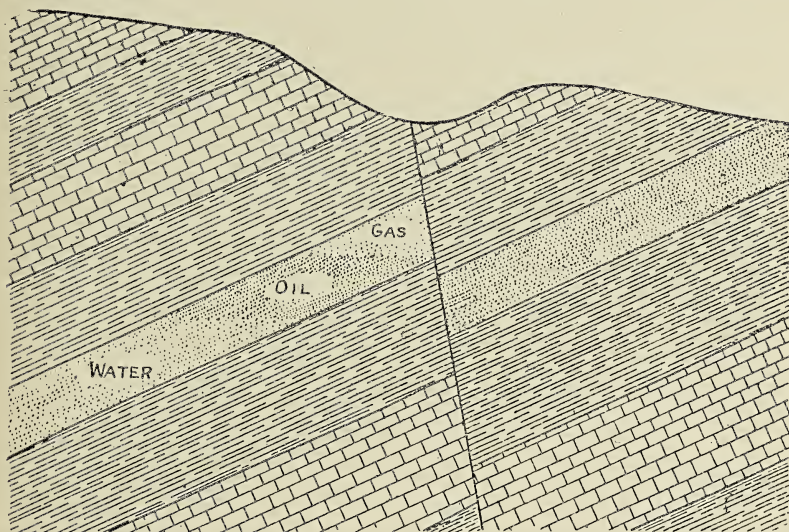


Fig 5. Diagram illustrating a fault affording conditions favorable to the accumulation of oil and gas.

DOMES

In its simplest form an anticline, as already stated, is an upfold or arch in the rock strata. A dome in its simplest form may be thought of as a bulging up of the strata. Anticlines are usually accompanied by compensating structures known as synclines. Domes may be, but are not necessarily, accompanied by compensating structures, which are basins. Domes serve as an ideal trap for oil and gas, since, being closed on all sides, the oil and gas entering them is retained. As seen in cross-section, a dome does not necessarily differ from a cross-section of an anticline. In fact, a dome may be regarded as an anticline, the axis of which is reduced to zero in length.

SALT DOMES

A very exceptional type of structure, often oil-bearing, is that known as salt domes. These domes are known near the Gulf of Mexico in

Texas and Louisiana, while similar domes are found in Roumania and some other of the European countries.

A remarkable feature of these saline domes is the fact that the central core of the dome consists usually, if not always, of a mass of salt. The depth to the salt core varies. In some of the domes the salt comes to, or practically to, the surface. In other domes the depth to salt varies from a few hundred to several thousand feet, while in a few domes the salt mass, although considered as with little doubt present, has not been reached in drilling.

Overlying the salt, as a rule, is gypsum, and with or above the gypsum is more or less sulphur. A so-called cap rock is usually present, consisting of limestone or dolomite. Above these strata, where they do not actually reach the surface, is a variable thickness of sands, clays and other sedimentary rock.

By what process these salt domes have been formed remains undetermined. Their importance as oil reservoirs arises from the fact that the salt and associated minerals have pushed up the sedimentary rocks, resulting in a dome structure favorable to the accumulation of oil.

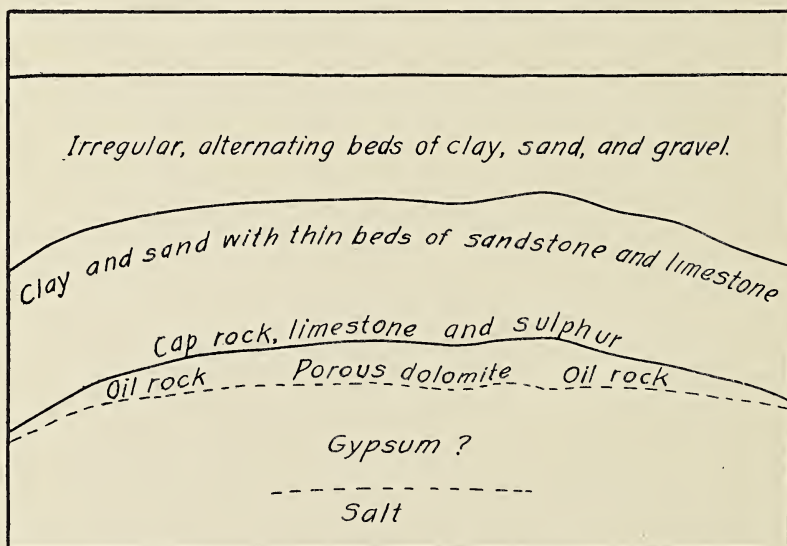


Fig. 6. Diagrammatic section through a salt dome. After Hager.

VOLCANIC PLUGS

Volcanic plugs or intrusions coming up into sedimentary rock, in some instances, push up the strata in such a way as to form storage reservoirs for oil.

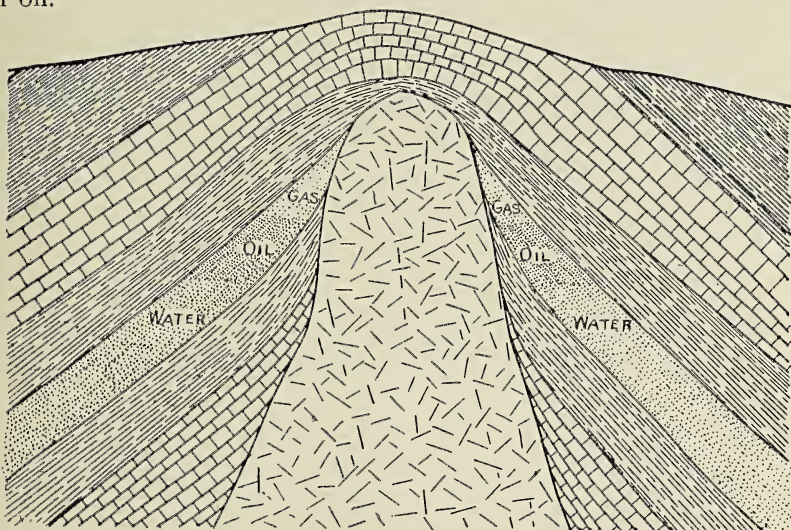


Fig. 7. Diagram illustrating conditions favorable to oil and gas accumulation by the intrusion of volcanic rock.

While some of the ways in which conditions may arise suitable for the storage of oil are thus accounted for, such enumeration of the structural conditions is necessarily incomplete. Any condition in the structure or arrangement of the strata within the earth that serves to trap and store oil and gas may afford production in commercial quantities.

DEPTH OF OIL WELLS

A question often asked is the depth to which it is necessary to drill to obtain oil. This question probably is prompted by the supposition that oil can be obtained at any place, provided drilling is carried to a sufficient depth. Such, however, is not believed to be the case. In some localities oil is obtained at a very shallow depth, while in other parts of the earth it is not reasonable to expect that oil can be obtained at any depth. At some localities oil has been obtained in commercial quantity at a depth of 100 feet or less. On the other hand, there are not a few

wells producing oil at a depth of from 4,500 to over 5,000 feet. In drilling, the cost increases greatly with depth, and hence only those wells that are large producers repay the expense of deep drilling. Conversely, small wells, if obtained at a shallow depth, may be very profitable.

METHODS OF DRILLING

. It is not the purpose in this paper to describe methods of drilling oil wells. It may be well to state, however, that two common methods of well drilling are in use, one by rotary and one by cable tools. Rotary drilling is practicable where the formations to be drilled through are relatively soft, but operates at a disadvantage in hard-rock formations. The cable tools are used to advantage where the formations are prevailingly hard. In the cable outfit, drilling is by means of a heavy drill which is alternately lifted and dropped, thus breaking or pounding its way through the rock. The broken or pounded up material is removed from the well by a bailer, the rock material being suspended in water. For a large cable rig such as is necessary for deep wells, a derrick is built at the well site by which to support and handle the machinery. On the market also are a number of well-drilling rigs of small size, which do not require a derrick, but operate by means of a portable center support.

The method of drilling by rotary is entirely different from that by cable tools. In the rotary drill a string of pipe extends from the top to the bottom of the well. This pipe revolves and, in doing so, cuts into the rock. The pieces of rock loosened in this operation are floated to the surface by means of a stream of water which is conveyed into the well through the drill stem and flows back around, that is, on the outside of the line of pipe.

The cable tool method of making a hole is usually regarded as desirable in drilling in a new territory. The character of rock drilled into is more readily determined when drilling by cable than by rotary. Also the mud carried by the rotary is likely to obscure small showings of oil such as might be detected by the cable method. On the other hand, where the formations are prevailingly soft, the cost of drilling by rotary is much less than by cable.

The possible use of the diamond drill is worthy of consideration. This method as at present developed is specially adapted to hard-rock forma-

tions, and operates at a disadvantage in soft formations. By means of the diamond drill, a continuous core is taken in the hard-rock formations, which is of great value in prospecting for oil and gas.

With respect to the drilling conditions in Florida it may be said that throughout much of the state a rotary drill may be used if desired. In the Eocene limestones are found flint nodules and occasional flint layers which may require a special bit for the rotary drill. The Tampa limestone, likewise, is somewhat flinty. In extreme south Florida and on the Florida keys are some rather hard limestones, such as the coral limestone of Key Largo and the fresh-water limestones of the Everglades. For the most part, however, the rotary may be used if desired.



Fig. 8. "Falling Water," four miles south of Chipley, Washington County. The test well of the Chipley Oil Company was drilled near this sink.

THE GEOLOGIC DISTRIBUTION OF OIL AND GAS

The oil first developed was chiefly from the Carboniferous and Devonian formations of Pennsylvania. Owing to this early development of oil in the United States from these older formations, the impression has become somewhat general that the late geologic formations are unfavorable as a source of petroleum. However, oil and gas are not confined to the formations of any one geologic age, but have been obtained from formations varying in age from the Ordovician to the Late Cenozoic.

GEOLOGIC TIME TABLE

For convenience of reference there is included here a geologic time table. In this table the time divisions are arranged in order, beginning with the most recent or Cenozoic.

Cenozoic	{	Quarternary.	{ Recent. Pleistocene.
		Tertiary.	{ Pliocene. Miocene. Oligocene. Eocene.
Mesozoic	{	Cretaceous. Jurassic. Triassic.	
Paleozoic	{	Permian. Pennsylvanian. Mississippian. Devonian. Silurian. Ordovician. Cambrian.	
Algonkian.			
Archean.			

With the exception of the Archean, Algonkian and Cambrian, probably all the time divisions given in this list contain petroleum-bearing formations. Notably large producing formations are found in the Tertiary, Cretaceous, Pennsylvanian, Devonian and Ordovician divisions.

The oil production of Louisiana is from the Cretaceous and Tertiary formations. In Texas, oil is obtained from the Tertiary, Cretaceous,

Permian, Pennsylvanian and Ordovician formations. In Oklahoma, oil is obtained chiefly from the Pennsylvanian and Mississippian formation. The Ordovician, Silurian and Pennsylvanian produce oil in the Lima Fields of Indiana and Ohio. The Mississippian and Pennsylvanian yield oil in Illinois. In the Appalachian Fields extending through New York, Pennsylvania, Ohio, West Virginia, Kentucky and Tennessee, production is obtained from formations of the Devonian, Mississippian and Pennsylvanian systems.

SURFACE INDICATIONS

Oil in the underlying formations is in some instances indicated by oil or gas seeps at the surface. It is, however, not to be assumed that seeps at the surface in all instances indicate oil in commercial quantities below the surface. On the other hand, it is also not to be supposed that oil below the surface will necessarily show as seeps. On the contrary, many valuable oil pools have been found of which there was, so far as known, no surface indication in the form of oil seeps.

Many reported oil and gas seeps are found on investigation to be something other than seeps of oil or gas. An iron oxide scum is very frequently mistaken for an oil scum. Iron is one of the very common mineral ingredients in soils, and where iron is present in some appreciable amount, the water of springs and small streams is very commonly covered with an oil-like scum. When an iron oxide scum is broken or disturbed it does not quickly reunite. An oil scum, on the contrary, reunites at once; an oil scum also if rubbed on the hands is not easily removed, while the iron oxide scum is readily removed by washing the hands.

Some gases other than petroleum gases are at times found coming from the earth. Thus, from some springs such gases as carbon dioxide or hydrogen sulphide are occasionally found escaping. Of these gases, however, carbon dioxide will not support a flame, and hydrogen sulphide may be recognized by its offensive odor. Not infrequently the presence of marsh gas is taken as an indication of the presence of petroleum. Marsh gas or methane is a gas of the paraffin series of petroleum compounds. This gas is, however, frequently found in decaying muck in bogs and swamps, and for that reason its presence does not necessarily indicate a gas seep from any considerable depth. In the case of marsh

gas, the observer must use judgment as to whether or not it is probably coming from decaying muck at the surface or from much deeper formations. Inflammable gas coming continuously with a strong flowing spring naturally is much more likely to be coming from a considerable depth than is gas that comes occasionally from swamp-mud deposits.

GEOLOGIC INVESTIGATIONS

The object of geologic investigation should be to determine whatever may be made known in regard to the property in advance of drilling or in addition to drilling, as the case may be. In these investigations the geologist will take into consideration the character of underlying sediments, whether petroliferous or not, and the probable depth of the producing horizons, if such are believed to exist. In determining probable structural conditions, evidence as to the position of the strata may be obtained by observations on the surface formations determining the direction and amount of dip. Or, data may be secured from deep well records in case wells have been drilled. Rarely, surface topography can be used to some extent to assist in determining underground structure. However, surface topography must be used with care. A topographically high area may or may not be a structurally high area. Occasionally a hill or mound at the surface coincides with an anticline or dome in the underlying formations, but it is very unsafe to assume such coincidence without proof. On the other hand, many instances can be cited where the anticline lies in a valley, or the structural dome is a basin at the surface.

In examining a property the geologist will take into account all structural features that can be determined. If favorable structure of any kind can be demonstrated or appears probable, recommendation to drill will then depend upon the probable character of the underlying formations. If the formations are believed to be not at all petroliferous, favorable structure is of no significance with respect to petroleum production. If, on the other hand, it can be shown that petroliferous formations underlie the area, the location on favorable structure would be desirable. The character of the underlying rock may be determined from cuttings, from wells previously drilled, if there are such, or may be inferred from outcropping of formations which, although coming to the surface some distance away, are nevertheless known by their position and direction of

dip to underlie the area in question. Oil or gas seeps would indicate petroliferous formations, but are not the only indications and are by no means always present, even in areas underlaid by oil or a gas.

GEOLOGIC FORMATIONS IN FLORIDA

The formations exposed at the surface in Florida fall within the latest of the major divisions recognized in geology, namely, the Cenozoic. However, some of the deeper wells in the state have reached formations of the next older division, the Cretaceous.

Following is a table giving the names that have been applied to the formations observed outcropping at the surface in Florida. In this table the formations are arranged in the order of their age, the younger formations being placed at the top, or as nearly in this order as is practicable, the relative age of certain of the formations not being fully determined:

Recent.

Pleistocene.

- Palm Beach Limestone.
- Miami Oolitic Limestone.
- Key Largo Limestone.
- Key West Limestone.
- Lostmans River Limestone.
- Ft. Thompson Beds.

Pliocene.

- Bone Valley Formation.
- Alachua Formation.
- Caloosahatchee Formation.
- Nashua Formation.
- Charlton Formation.

Miocene.

- Choctawhatchee Formation.
- Jacksonville Formation.
- Alum Bluff Formation.

Oligocene.

- Tampa Formation.
- Chattahoochee Formation.
- Marianna Formation.

Eocene.

- Ocala Formation.

Cretaceous, known in Florida only from well records.

LITHOLOGIC CHARACTER AND GEOGRAPHIC DISTRIBUTION OF THE FLORIDA FORMATIONS

A description of the Florida formations and much data on their geographic distribution have been given in previous reports of the Florida Geological Survey. It will not be necessary, therefore, to describe these formations in detail. It is, however, desirable to give briefly the lithologic characteristics and geographic distribution of each of the formations. These will be discussed in order, beginning with the oldest of the formations found exposed at the surface.

EOCENE

OCALA FORMATION

The Ocala formation consists, for the most part, of a white limestone; rarely in Florida does this formation contain more than a limited amount of sand, and little or no clay. The rock is prevailingly granular in texture with an abundance of small and large shells and shell fragments. The Ocala formation is found in two separate areas in this state. It is found at the surface over small areas west of the Apalachicola River, and may be seen in exposures on the Chipola River at and above Marianna and for a short distance farther down stream. The Ocala at Marianna is a thin formation, according to Cooke, not exceeding about 20 feet.

The second area in the state where this formation is found at or very near the surface is in central peninsular Florida. The Ocala limestone belt of this part of the state extends in a north-south direction through Suwannee, Columbia, Alachua, Marion, Sumter, Citrus and Hernando Counties. The formation as now understood has no great thickness, probably scarcely exceeding 50 feet on an average. Locally, this limestone has been altered by action of ground water to a compact, close-grained rock. In places also it contains masses or layers of flint. Among foraminifera, abundant in this formation, according to Cushman, are species of *Lepidocyclus*, *Heterostegina*, *Operculina* and *Orthophragmina*. Directly under the Ocala, possibly in the Claiborne, is a horizon in which *Nummulites* is abundant.¹ The fossils of the Ocala formation, aside from the foraminifera, have been described by Dall² and more recently reviewed by Cooke.³

¹Fla. Geol. Surv., 12th Ann. Rept., p. 96, 1919.

²Trans. Wagner Free Institute of Sci., Vol. III, pt. VI, pp. 1556-1558, 1903.

³U. S. Geol. Surv., Professional Paper 95, pp. 107-117, 1915.

OLIGOCENE

To the Oligocene are referred three formations, namely, the Marianna, Chattahoochee and Tampa. The Chattahoochee and Tampa formations are suspected of being in part, at least, contemporaneous. The relation of the Marianna to the Chattahoochee has not been well established.

MARIANNA FORMATION

The Marianna formation is prevailingly a light-colored, granular limestone. It is known in Florida only in the limestone area west of the Apalachicola River where it overlies the Ocala limestone, and except by a study of the fossils is with difficulty distinguished from that formation. The Marianna is regarded as the equivalent of a part, at least, of the Vicksburg formation of Mississippi and Alabama. The Marianna is a thin formation; its full thickness has not been determined, but in the section at the public road crossing on the Chipola River at Marianna 33 feet of this formation, according to Cooke, is exposed. In this section the base of the formation is seen, but some of the upper part probably has been removed by erosion.

CHATTAHOOCHEE FORMATION

The Chattahoochee formation differs from the Marianna in that it contains an appreciable clay ingredient. It is in fact a clayey limestone containing relatively few fossils. This limestone is found exposed on and near the Apalachicola River at the Georgia-Florida state line and for some 12 miles down this stream and at a number of localities west of this river. It is seen again on the Ocklocknee River from the state line to the crossing of the Seaboard Air Line Railway. East of the Ocklocknee River it is found at the surface in places in Leon, Wakulla, Jefferson, Madison, Taylor, Lafayette, Dixie and Suwannee Counties. It is apparently quite generally absent in central peninsular Florida, where formations of later age in places rest directly upon the Ocala limestone. East of the Ocklocknee River the rock is a hard and relatively pure limestone, differing in this respect from the clayey phase of the rock as seen on the Apalachicola River. The thickness of the Chattahoochee formation is probably between 100 and 200 feet.

TAMPA FORMATION

The name Tampa formation has been applied to what is probably in a large part the equivalent of the Chattahoochee formation on the gulf side of southern Florida. This rock is found at the surface in Hernando, Hillsborough and northern Manatee Counties. It is well exposed on the Hillsborough River, where it is seen to be a relatively hard limestone in places, as on Tampa Bay, containing flint and chalcedony. The fossils of the Tampa formation have been described by W. H. Dall in Bulletin 90 of the U. S. National Museum, 1915.

MIOCENE

ALUM BLUFF FORMATION

The Alum Bluff, the oldest of the Miocene formations, is perhaps the most widespread of the formations seen at the surface in Florida. The materials of this formation include more or less calcareous sands and sandstones, becoming in places sandy limestones. The formation contains likewise sandy and calcareous clays, as well as non-calcareous clays of the variety of fuller's earth. The fossils of the formation are in part such as are found under shallow water marine conditions and are in part land and fresh-water animals and plants, the sediments having evidently accumulated near shore. The thickness of the formation may in places reach 200 feet, although it is as a rule much thinner.

This formation is found extensively developed in peninsular Florida and in west Florida, as indicated on the geologic map. The westward extension of this formation contains extensive marine shell beds or marls. From the Apalachicola River south through peninsular Florida, the formation contains more or less phosphatic material, either in the form of small brown, black or light-colored concretions, or as a finely disseminated phosphate in a matrix of sand and clay. The phosphatic phase of this formation, however, is not to be confused with the much richer phosphate deposits which form the phosphates of commercial value. The phosphates now being mined, although representing concentrates from the Alum Bluff formation, are in their present form of much later date, probably Pliocene.

The shell marl deposits of this formation in west Florida have received distinctive names as members of this formation. The marl near the base of the formation seen exposed at Bailey's Ferry on the Chipola River, at Alum Bluff on the Apalachicola River, and at Jackson Bluff on the Ocklocknee River is known as the Chipola marl. Another member, the Oak Grove sand, is seen on Yellow River in west Florida. Somewhat higher in the formation is the Shoal River member, seen on Shoal River.¹

JACKSONVILLE FORMATION

The Jacksonville formation was named from exposures seen in excavations at Jacksonville, which unfortunately are not available for examination at the present time. Subsequently the term was applied to deposits exposed on Black Creek, in Clay County. The Clay County deposits are lithologically very similar to certain phases of the Alum Bluff formation, consisting of phosphatic marls, prevailing yellow in color, the phosphate being for the most part in the form of small, round pebbles. The fauna, however, is supposed to indicate a later age than that of the Alum Bluff formation.

¹Fla. Geol. Surv., 2nd Ann. Rept., 1909.

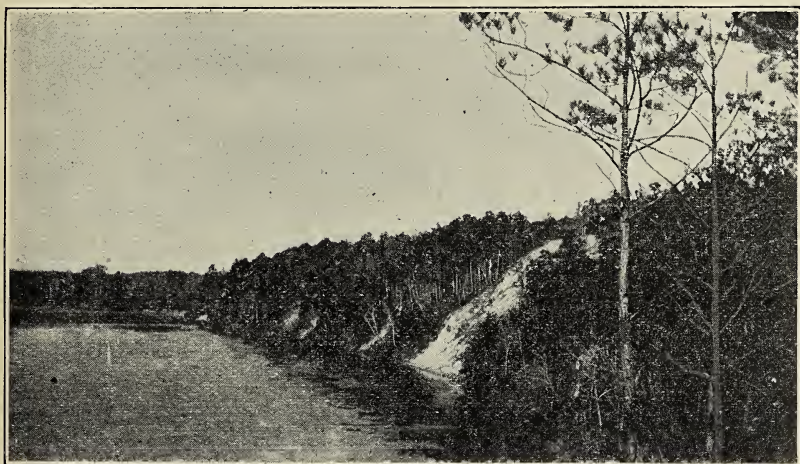


Fig. 9. The Apalachicola River showing Alum Bluff.

CHOCTAWHATCHEE

The Choctawhatchee formation has but a limited development in west Florida, where it consists of beds of marine shells in a sandy or clayey matrix. These marl beds, which seldom exceed 20 to 50 feet in thickness, extend in a narrow belt of occasional outcroppings from Leon County east of the Ocklocknee River, west or slightly north of west, to a little beyond the Choctawhatchee River.

PLIOCENE

The Pliocene of Florida consists of relatively thin marine and estuarine or fresh-water sediments. The marine sediments are chiefly shell marls with a sandy or clayey matrix. They include the Nashua marls of the St. Johns River basin and the Caloosahatchee marls of the Caloosahatchee basin, and the Charlton formation of the St. Marys River Valley in northeast Florida.

The sediments, which are of estuarine and fresh-water origin, include the Bone Valley and Alachua formations. The first named is found chiefly in Polk, Manatee and Hillsborough Counties. The deposits consist chiefly of sand, clay and pebble phosphate. The Alachua formation, probably contemporaneous with the Bone Valley, is found in Alachua, Marion and Levy Counties, and contains the hard-rock phosphate deposits. In addition, some of the undifferentiated surface materials are probably of Pliocene age.

PLEISTOCENE

The Pleistocene formations attain their maximum development in Florida in the southeastern part of the peninsula, where marine and fresh-water limestones cover a considerable area. Even at the extreme south end of the peninsula, however, the Pleistocene attains no great thickness. In wells on the Florida keys the Pleistocene beds are believed not to exceed about 125 feet. Description of these formations in some detail will be found in the earlier reports of the Florida Survey. Superficial materials, in part, of Pleistocene age are found over large areas in the state.

GEOLOGIC MAP

The surface distribution of the formations is indicated on the accompanying geologic map. On this map surficial materials are to a degree neglected and the deeper formations are mapped over areas in which they, in some instances, only occasionally outcrop. Thus in the large area in central peninsular Florida mapped as Ocala, the outcrops of this formation are by no means continuous, this formation being very commonly mantled by remnants of the Alum Bluff formation, and in places by the reworked products of the Alum Bluff and other formations which now constitute the Alachua formation. A detailed map on a larger scale would show within the area here assigned to the Ocala, isolated remnants of the Alum Bluff formation as well as of the Alachua formation. Likewise the considerable area, particularly in west Florida and on the Atlantic coast mapped as Pleistocene and Pliocene, includes, as indicated, more or less undifferentiated formations, some of which possibly will be found to be older than the Pleistocene or Pliocene.

The mapping of the Choctawhatchee formation, upper Miocene, presents difficulties owing to the fact that it is very thin and is frequently cut through by streams. To the east, the shell marl phase of this formation seems definitely to end somewhat west of Tallahassee. Its extension to the west is much less definitely known, although the westernmost fossiliferous locality seen at the surface is that at Red Bay, in Walton County. The mapping of the formation as extending farther to the west is therefore hypothetical. On the geologic map it is shown to extend westward to the Alachua Creek in central Walton County. This mapping of the westward extension of the formation is by Dr. C. Wythe Cooke.

The mapping of the Upper Miocene, as extending to the gulf through Franklin County, is hypothetical except in so far as supported by a fossiliferous locality on New River which indicates either Miocene or Pliocene. (See page 103.)

The Chattahoochee and Alum Bluff formations west of the Apalachicola River have been mapped by C. Wythe Cooke. These formations east of this river are mapped as the surface formations in the northern part of Leon, Jefferson and Madison Counties. As a matter of fact, there is quite generally spread over this area a superficial deposit of red sand and clay, the age and relationship of which is undeter-

mined. These surface deposits were originally referred to the Lafayette, but there are some reasons for regarding a part of this material as merely the residue from the Alum Bluff formation. In Gadsden County, as well as in some other parts of the state, these red sands and sandy clays, the distribution of which is not indicated on the geologic map, attain a considerable thickness.

The marine and fresh-water Pleistocene of extreme southern Florida has been represented in some detail on the map previously published by the Survey, and in this part of the state this earlier map has been followed without alteration.

In the interior of the state there is, with little doubt, much Pleistocene that should be represented on a detailed map, but since in a report on the oil possibilities we are scarcely concerned with the thin surface formations, the Pleistocene of the interior of the state will not be further discussed at this time.

The distribution of the Charlton formation, as shown on this map, is essentially in accordance with the description of the formation given by Stephenson and Veatch in their report on the geology of Coastal Plain of Georgia.¹

No attempt has been made to map the Alachua formation. These deposits are relatively thin and rest upon the Eocene of central peninsular Florida. For a map showing the distribution of this formation, reference may be made to the Fifth Annual Report of this Survey. Likewise no attempt has been made to separate the Jacksonville and Alum Bluff formations in northeastern Florida.

The mapping of surface materials of the Lake Region of peninsular Florida presents considerable difficulty. The superficial deposits in the Lake Region, in peninsular Florida as far south as Highlands County, consist of sands, gravels and clays, and in places kaolin beds, the age of which is undetermined. It is known that in some localities materials of this character overlie the Alum Bluff Miocene, or at least the fuller's earth horizon of that formation. It may be, however, that these materials represent the uppermost part of the Alum Bluff formation, or they may be a part of the Upper Miocene or Pliocene, or even possibly Pleistocene. In the absence of fossils, the determination of the age of these sediments presents unusual difficulties. Nor can it be asserted that the

¹U. S. Geol. Surv., Water Supply Paper No. 341, 1915.

superficial materials of the Lake Region, as a whole, represent a unit formation. In this map, the Lake Region is included within the mapping of the Miocene, but this disposition is made with the reservations here stated.

STRUCTURAL FEATURES

It is not possible with the data that has thus far accumulated to discuss geologic structure in Florida in detail. However, certain major structural features exist which are apparent, both from the areal geology and from the deep-well records.

In that part of Florida adjoining Alabama, and lying west of the Apalachicola River, there is evidently a structurally high area which extends into Florida from Alabama and Georgia. The location of this area is indicated in the areal mapping. By referring to the geologic maps of Alabama, Georgia and Florida, it will be seen that the trend of the Eocene formations in Alabama is slightly south of east, bringing them into Florida in Holmes County. These formations lie at or near the surface in the northern part of Holmes and Washington Counties, and in the greater part of Jackson County. Before reaching the Apalachicola River, however, the trend of these formations changes abruptly to about due northeast. The dip of the Eocene formations in Holmes County is probably southwest. The dip in the eastern part of Jackson County is with little doubt southeast. When this part of the state is contoured on the Oligocene formations, there is seen to be a very broad nose extending into Florida which can be traced to, or nearly to, the shore line of the Gulf of Mexico. (See map in Florida Survey, 11th Annual Report, page 80, 1918.)

With regard to Florida, east of the Apalachicola River, it will be observed from the mapping of the areal geology that the late Eocene comes to the surface in a large area in central peninsular Florida, and is then surrounded except on the west or gulf side by later formations. It is believed that the Alum Bluff Miocene formerly entirely covered the Eocene and has subsequently disappeared by erosion. However, the exposure of the Eocene indicates a true doming in this part of the state. A consideration of the actual position of the Eocene in this part of the state will reveal dips to the south, east and north from the areas of surface exposures, detected by well records showing the depth at which the Eocene is entered in wells. A dip to the west is probable, although

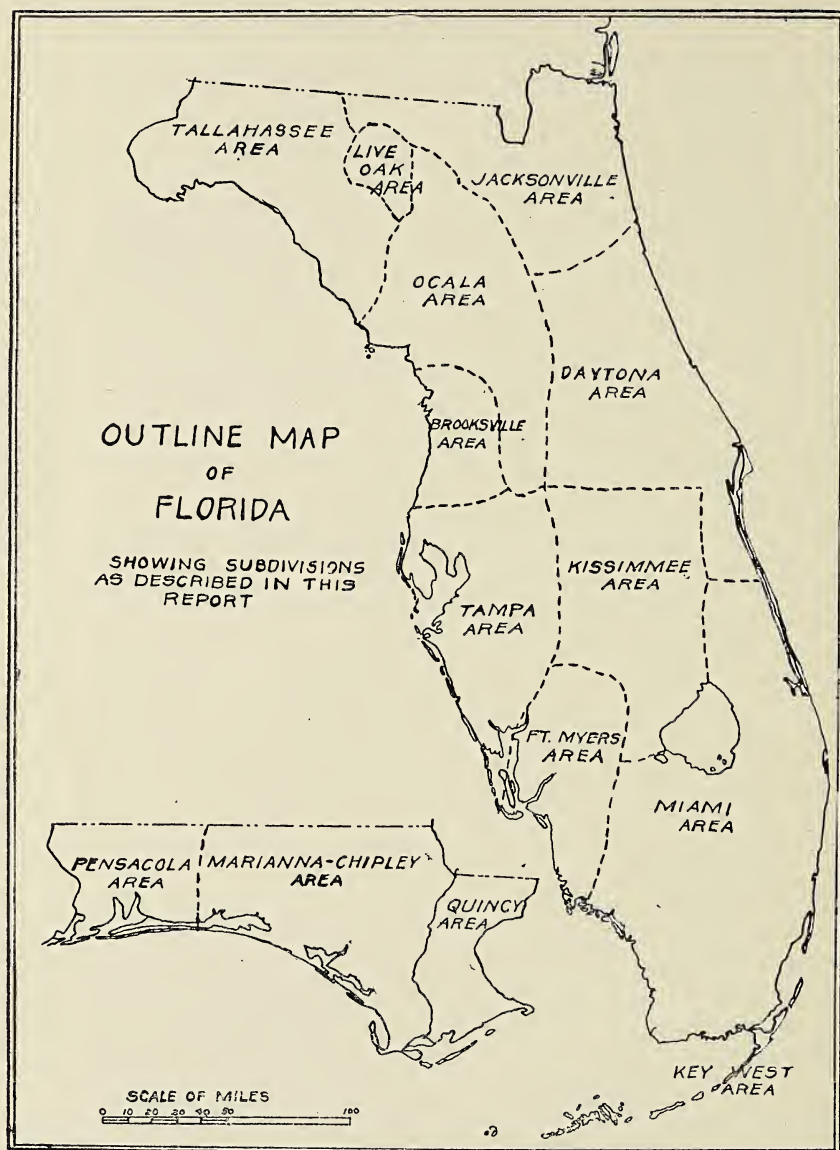


Fig. 10. Sketch map showing areas in Florida referred to in this report.

it can not be so readily detected, since the Eocene lies at the surface to the Gulf of Mexico and is so massive in character as scarcely to reveal dips.

In the Twelfth Annual Report, issued in 1919, the geology of Florida was discussed with regard to the structural conditions in the state and on the map which accompanied that report are indicated the pronounced structural features of the state.

A description of a structural dome in the vicinity of Live Oak has been given in the Thirteenth Annual Report of this survey. The area lying between the Suwannee and Ocklocknee Rivers is described in this report under the heading Tallahassee area, and it is shown that this area, in the vicinity of Tallahassee, lies structurally higher than does the area between the Ocklocknee and Apalachicola Rivers. A remarkable feature of all of the area from Tallahassee east into peninsular Florida is the absence apparently of the Upper Cretaceous formations and the near approach to the present surface of the Lower Cretaceous.

GEOLOGIC SUBDIVISIONS

Since the state of Florida includes a large area approximating in extent 400 miles in an east-west and somewhat more than 400 miles in a north-south direction, it is to be expected that the formations to be penetrated and the drilling conditions will vary a good deal from place to place. Hence a discussion of the formations to be encountered and the drilling conditions to be expected will be facilitated by dividing the state into several of more or less natural geologic provinces, for each of which the formation and drilling conditions are more or less uniform.

If we examine that part of Florida west of the Ocklocknee River, that is, the westward extension of Florida from near Tallahassee, we shall find that in extreme west Florida the Eocene and Oligocene formations are deeply buried beneath later sediments, while from Walton County east to the Apalachicola River these formations are occasionally exposed at the surface. Between the Apalachicola and Ocklocknee Rivers the Miocene and later formations are at the surface, thus constituting three natural geologic divisions west of the Ocklocknee River.

East of the Ocklocknee River and extending to the Suwannee River is a part of the state in which a thin remnant of the Miocene overlies

the Oligocene. At or near the Suwannee River in going east we enter the extensive area of central peninsular Florida where the Eocene, except for occasional remnants of other formations, is at the surface. This belt of Eocene extends south to Sumter and Citrus Counties, west to the Gulf of Mexico and east to eastern Alachua and central Marion Counties. Beneath a thin covering of Eocene limestones in most, if not all, of this region, are found Cretaceous sediments.

To the south of this area on the Gulf side of the peninsula, including southern Hernando, Pinellas and Hillsborough Counties, the Oligocene lies at the surface, while farther to the south, as well as to the east, the surface formations are those of the Miocene and later periods.

On the accompanying sketch map are indicated the subdivisions into which the state may conveniently be divided for descriptive purposes, and in the following pages will be found an account of the formations to be penetrated and the drilling conditions to be expected for each subdivision.

In order to facilitate comparison with adjoining states there is included here a table in which is given the principal formations as recognized in the coastal plains of the Gulf States. The formations known to be oil-bearing in places and under favorable structural conditions are indicated in the table by a star. (See following page.)

GEOLOGIC SUBDIVISIONS IN FLORIDA WEST OF THE SUWANNEE RIVER

THE MARIANNA-CHIPLEY AREA

The Marianna-Chipley Area lies west of the Apalachicola River and includes all or part of the following counties: Jackson, Holmes, Washington and Walton. Bay and Calhoun Counties lie between this area and the Gulf coast. The surface formations in this area, as already noted, are those of the Oligocene and Eocene with Miocene coming into the section to the east, south and west. Underneath the surface formations in this area are to be found other Tertiary and the Cretaceous series of formations.

The Tertiary formations include the following, named in the order in which they are encountered in drilling: Ocala, Claiborne, Wilcox and Midway. Of these the Ocala is regarded by Cooke as the equivalent of

TABLE OF PRINCIPAL GULF COASTAL PLAIN FORMATIONS.

	West Texas	East Texas	Louisiana	Mississippi	Alabama	Georgia	Florida
Pleistocene	Terraces Beaumont Reynosa Lissie	Terraces Beaumont Lissie	Terraces Beaumont (Port Hudson) Lissie	Terraces Port Hudson Natchez	Terraces Lafayette (in part)	Terraces	Terraces Palm Beach Miami Key Largo Key West Lostmans River Fort Thompson
Pliocene	Terraces Legarto Lepara	Terraces Citronelle Fleming* (in part)	Terraces Citronelle	Terraces Citronelle	Terraces Citronelle Lafayette (in part)	Terraces Charlton	Terraces Bone Valley Alachua Caloosahatchee Nashau Charlton
Miocene	Oakville	Fleming* (in part)	Pascagoula* (Fleming)	Pascagoula	Pascagoula	Marks Head Dublin Bluff Alum Bluff	Choctawhatchee Jacksonville Alum Bluff
Oligocene		Catahoula (Corrigan)	Hattiesburg Catahoula Vicksburg	Hattiesburg Catahoula Vicksburg	Hattiesburg Catahoula Vicksburg	Chattahoochee Vicksburg (Marianna)	Tampa Chattahoochee Marianna
Eocene	Frio Fayette* Claiborne Yegua* Cook Mt.* Mt. Selman Carrizo	Jackson* Claiborne Yegua Cook Mt.* Mt. Selman Queen City	Jackson Claiborne Yegua St. Maurice	Jackson Claiborne Lisbon Tallahatta	Jackson Claiborne Gosport Lisbon Tallahatta	Jackson (Ocala)	Ocala Not exposed at surface
	Wilcox Midway*	Wilcox Midway	Wilcox Midway	Wilcox Midway	Wilcox Midway	Wilcox Midway	Not exposed at surface Not exposed at surface
Upper Cretaceous	Navarro* Taylor** Austin* Eagle Ford Woodbine*	Arkadelphia Nacatoch* Marlbrook Annona* Brownstown Blossom* Eagle Ford Woodbine*	Arkadelphia Nacatoch* Marlbrook Annona* Brownstown Blossom* Eagle Ford Woodbine*	Ripley Selma Eutaw	Ripley Selma Eutaw	Ripley Eutaw	Not exposed at surface
Lower Cretaceous	Thick deposits variously sub- divided. Pro- duces some oil.	Not exposed. Produces some gas from deep wells.	Not exposed. Produces oil from deep wells.	Tuscaloosa	Tuscaloosa	Undifferen- tiated.	Not exposed at surface

Formations known to have produced oil and gas indicated by a star.

the upper part of the Jackson formation of Alabama.¹ Over this area in Florida this formation is thin and in places possibly entirely absent.

The Claiborne formation, or series of formations, is found extensively developed in Alabama, and in that state the group is divided by Smith into three formations as follows: The Gosport Greensand at the top, followed by the Lisbon formation and the Tallahatta buhrstone.

The uppermost of these formations, the Gosport, has in Alabama a thickness not exceeding 30 feet, and consists of highly fossiliferous glauconitic sands. The Lisbon is said to include, in Alabama, about 115 feet of calcareous sandy clays and clayey sands. The Tallahatta buhrstone, the lowermost formation of the Claiborne, has, according to Smith, a thickness, in eastern Alabama, of about 200 feet. The rocks of this formation in Alabama are quite calcareous.

Thus the whole thickness of the Claiborne in eastern Alabama, according to Smith, approximates 345 feet. The group of formations of the Claiborne as there developed include extensive beds of greensand. Whether the Claiborne Group will be found to thin out or to become thicker in Florida has not been determined.

The Wilcox Group of formations, which lies next below the Claiborne, outcrops at the surface in Alabama a few miles north of the north Florida boundary. The Wilcox Group has been separated in Alabama on the basis of the fossils, into four formations which are in order as follows, beginning with the uppermost or latest of the series: Hatchetigbee, Bashi, Tuscahoma, and Nanafalia. These formations, according to Smith, consist of cross-bedded sands, thin-bedded or laminated sands, laminated clays and clayey sands, with beds of lignite or lignitic matter sufficient to color the sands and clays.²

The formations are notably variable in lithology and the separate members probably could with difficulty be distinguished in well records. The entire series in Alabama has a thickness of approximately 900 feet.

The basal Tertiary sediments, the Midway Group, include in eastern Alabama, according to Smith, approximately 200 feet of calcareous sands and limestones.

A well located in the Marianna-Chipley region, starting in the Upper Eocene or Lower Oligocene, may therefore be expected to encounter 1,500 or 2,000 feet of Tertiary sediments before entering the Cretaceous.

¹U. S. Geol. Surv., Professional Paper 95, p. 117, 1915.

²Underground Water Resources, Ala. Geol. Surv., 1907, p. 16.

THE CRETACEOUS SEDIMENTS

The nearest Cretaceous sediments exposed at the surface are found in Alabama some 50 or 60 miles north of the Florida state line. These sediments, the Ripley, Selma, and Eutaw formations of the Upper Cretaceous and the Tuscaloosa formation of the Lower Cretaceous, dip toward the coast and presumably underlie the Tertiary sediments of west Florida.

Of these formations, the Ripley and Eutaw in Alabama include chiefly calcareous sands and clays. The Tuscaloosa likewise is a formation consisting largely of sands with beds of clay. The Selma, on the contrary, is chiefly a chalk formation with some clay. The Selma chalk, in Alabama, according to Smith, extends but a short distance east of Montgomery, and hence in eastern Alabama, north of the area under consideration in Florida, consists largely of calcareous sands and clays.

WELL RECORDS

A well was begun June 29, 1919, by the Chipley Oil Company about four miles south of Chipley as a test for oil. The exact location of this well is the NW $\frac{1}{4}$ of the NW $\frac{1}{4}$ of Sec. 27, T. 4 N., R. 13 W., and is near the locality known as Falling Water sink. Fortunately, a very complete and accurate record has been preserved, based on samples of the drillings taken at five-foot intervals, and these were submitted to the Florida Geological Survey for study through the courtesy of Mr. E. C. Butler. The well has a total depth of 4,912 feet, being abandoned at that depth on May 31, 1921.

The successive formations penetrated in this well are scarcely to be recognized by the lithology of the formations and can be identified, if at all, apparently only by the minute fossils which have not yet been studied in detail. All data relating to the geologic succession of formations as revealed by a study of these samples will ultimately become available.

EXTREME WEST FLORIDA—PENSACOLA AREA

The part of the State here described as the Pensacola area includes Escambia, Santa Rosa and Okaloosa Counties. In this area the surface formations include Miocene and later formations. The south and southwest dip observed in the formations of the Marianna-Chipley district

carries the Oligocene and Eocene formations to a considerable depth in this part of the State. Thus the limestones which lie at the surface as far west as northern Walton County and western Holmes County underlie Pensacola at an unknown depth.

A well drilled at or near Pensacola will penetrate several hundred feet of sediments, chiefly sands and clays and shell marls, before reaching the limestones which lie at the surface at Marianna, Chipley and in Walton County. After reaching these limestones, the succession of formations, although unknown by actual test, may be more or less similar to that of the Marianna-Chipley region, or may differ owing to changed conditions of deposition.

The following record of a well at Pensacola indicates in a general way the character of the sediments to a depth of 1,607 feet. The total depth of the well is given as 1,620 feet.

*Log of Well No. 2, Drilled on East Hill, Pensacola, by the Pensacola Development Company**

	<i>Depth in feet.</i>
Variegated clays	0- 18
Iron-stained sandstone	18- 19
Coarse orange sands becoming white with gravel at bottom (plenty of water standing 28 feet down from surface)	19- 52
Variegated clays with fine sand	52- 170
Coarse white sand (water stood only 46 feet below surface)	170- 185
Gray clay	185- 228
Gray sand becoming finer at bottom	228- 255
Blue clay	255- 291
Gray sand	291- 305
Soft grayish clay becoming harder at bottom	305- 339
Sandstone	339- 340
Green clay	340- 358
Sandstone	358- 359
Green clay	359- 372
Sandstone	372- 373
Greenish clay	373- 453
Fine green sand (water stood 36 feet below surface)	453- 468
Hard greenish clay	468- 583
Greenish-gray sand (water about 40 feet below surface)	583- 605
Very hard clay, blue-green in color	605- 725
Gray sand (water 40 feet below surface)	725- 761
Very hard green clay	761- 901
Fine greenish sand	901- 921
Hard green clay	921- 991
Rock	991- 992
Clay becoming hard, greenish in color	992-1145
Fine greenish sand	1145-1162
Very hard greenish clay	1162-1245

*U. S. Geol. Surv., Water Supply Paper No. 102, p. 258-9, 1903.

	<i>Depth in feet.</i>
Gray sandstone.....	1245-1252
Soft greenish clay.....	1252-1255
Sandstone	1255-1269
Greenish clay	1269-1292
Limestone and sandstone in layers.....	1292-1342
Phosphate rock	1342-1356
Sandstone	1356-1367
Phosphate rock	1367-1371
Hard and soft rock (limestone and sandstone).....	1371-1421
Very fine gray sand (flow of about 10 gallons per minute of salt water at a temperature of 103°)	1421-1432
Greenish-gray clay beds from 2 to 20 feet thick, full of shells and small sharks' teeth, alternating with limestone and sandstone beds.....	1432-1547
Sandstone rock with layers of phosphate rock (salt water found again at depth of 1470)	1547-1607
No indications of oil were found.	

The formations penetrated in this well can scarcely be identified from the log. From fossils obtained from a well at Cantonment it is known that the Miocene is present, underlying this part of the State.*

THE QUINCY AREA

The belt of country lying between the Apalachicola and Ocklocknee Rivers, including Gadsden, Liberty and Franklin Counties, is in some respects distinctive. This area is topographically high, including some of the maximum elevations found in Florida. There are reasons for believing, however, that structurally this area is lower than is the region either to the east or west. The surface formations exposed in this area range from the Oligocene to the Pleistocene or recent formations near the coast. The Chattahoochee limestone (Oligocene) is found in stream channels and sinks in the northern part of the area. To the south it dips beneath later formations. The Lower Miocene, the Alum Bluff formation, is found over the northern one-half or more of the area, while the Upper Miocene (Choctawhatchee formation) covers a narrow belt extending approximately east-west across the area.

Wells located in the northern part of this area start near the top of the Oligocene or in the Miocene. The Miocene sediments are chiefly shell marls, clays and sands. The Oligocene represented by the Chattahoochee limestone will possibly be found to have a thickness approximating 100 or 200 feet. The succession below the Chattahoochee lime-

*Fla. Geol. Surv., 2nd Ann. Rept., p. 117, 1909.

stone is but imperfectly known from drilling records, but may be inferred from exposures and records elsewhere. A well drilled near Greensboro, as indicated by samples seen on the dump, reached limestones of Eocene age. The depth and thickness of the limestone, however, was not determined. The well was drilled to a total depth of about 1,750 feet.

The character of materials to be drilled through in this area is indicated by the following log of a well drilled at Quincy:

*Partial Log of the Well of the Owl Commercial Company at Quincy**

	<i>Feet.</i>
Quartz sand, fine to coarse, white.....	101 - 449
Clay, yellow	110 - ...
Limestone, white, soft, sandy, or marl.....	118 - 132
Clay, light brownish.....	133½ - 154
Limestone, soft, white, light gray, and greenish; lots of fossil shells...	191 - 200
Limestone, hard, light brownish; lots of shells.....	... - 200
Limestone, soft, white, and greenish clay.....	200 - 210
Clay, dark brown.....	260 - 263½
Quartz sand, medium white; bits of limestone and dark-brown clay...	... - ...
Sand, coarse, light gray, or greenish, limey, or soft, sandy limestone...	284 - 287
Limestone, hard, porous, gray, and brownish.....	289 - 290
Same; partly silicified.....	290½ - ...
Limestone, soft, porous, white.....	302 - 309
Limestone, soft, light drab, sandy.....	315 - 316
Limestone, soft, light drab.....	319 - 322
Same	... - ...
Marl, gray, sandy.....	391 - 392
Marl, light gray, sandy, or soft limestone.....	410 - 412
Marl, light drab, or soft limestone.....	442 - ...
Clay or soft shale, light gray and greenish, limey.....	453 - 454
Limestone, porous, white.....	470 - 474
Limestone, white and light, porous.....	476 - 480
Limestone, hard and soft, light brownish.....	491 - 495
Same; fragments of shells and coal (?).....	495 - 505
Same	506 - 507
Same; hard layer, more or less crystalline.....	508 - 529
Limestone, brown, porous, sugary-looking.....	562 - 566
Same	566 - 574
Limestone; white and light brownish; made up of bits of shells, Bryozoa and Nummulites	576 - ...
Same; white and light brownish.....	591 - 593
Limestone, light brown, porous, sugary-looking; denser and gray in places	618 - 625
Limestone, light brown, porous, sugary.....	623 - 637
Limestone, light brownish, porous.....	672 - 680
Limestone, light brownish.....	693 - 699
Limestone, white; with numerous fragments.....	699 - 704
Same; with Orbitoides (?).....	705 - 713
Limestone, porous, light brownish.....	728 - ...

*U. S. Geol. Surv., Water Supply Paper 319, pp. 310-311, 1913.

	<i>Feet.</i>
Same; with Orbitoides (?); has siliceous strata.....	749 - 755
Same; with bits of shells, Bryozoa and Nummulites.....	755 - 766
Limestone, light brownish.....	781 - ...
Bits of Bryozoa.....	800 - ...
Limestone, soft, brownish; with brown chert.....	827 - 840
Limestone, light brownish.....	859 - 865
Same; with Bryozoa.....	876 - 881
Same; gray, limey shale.....	905 - ...
Limestone, light brownish.....	952 - 962
Limestone, light brownish; with bits of shells and Bryozoa.....	983 -1001

The limestones in this well at the depth of 491 to 529 feet were identified by Bassler as Eocene on the evidence of the Bryozoan fossils.¹ From the log it would appear probable that the Eocene limestones were entered at 470 feet. The thickness of the Eocene in this well is undetermined.

THE TALLAHASSEE AREA

From the Ocklocknee to the Suwannee River, exclusive of Hamilton County, is an area including Leon, Wakulla, Jefferson, Madison, Taylor, Lafayette and Dixie Counties, which may be known as the Tallahassee Area. In this belt of country the Chattahoochee limestone is, as a rule, either at the surface or sufficiently near the surface to be occasionally exposed in deep sinks and stream beds, although near the Suwannee River, in Dixie County, there are exposures of the Ocala formation. Overlying the Oligocene is found more or less of the Miocene which formerly covered the area. Structurally, this area is believed to lie higher than does the area between the Ocklocknee and Apalachicola Rivers.

Wells within this area start within, or but little above, the Chattahoochee formation. Beneath the Chattahoochee it would appear that no more than a thin development of Eocene limestone is present. Underneath the Eocene, according to Cushman's identifications, the Upper Cretaceous is entirely wanting, the drill passing at once from the Eocene into the Lower Cretaceous.²

The following record of a well located in Wakulla County indicates the character of the rocks to a depth of 2,169 feet:

¹U. S. Geol. Surv., Water Supply Paper 319, p. 310, 1913.

²Fla. Geol. Surv., 12th Ann. Rept., p. 82, 1919.

Record of well No. 1 of Bonheur Development Company. Well located at Burns, in Wakulla County, sixteen miles south of Tallahassee. Based on samples collected by Mr. B. M. Cates and submitted to the Florida Geological Survey. Well begun May 1, 1916, completed June 1, 1919, to total depth of 2,169 feet.¹

	<i>Depth in feet.</i>
The limestone at the surface at this locality is the Chattahoochee formation, and is the same rock that is found on the Apalachicola River near River Junction, and on the Suwannee River near Live Oak.	
The sample from the depth of 50 feet is a light-colored limestone which contains a few echinoderm spines and small foraminifera.....	50
The rock at this depth is a brown, porous limestone. Aside from echinoderm spines, no fossils were found in this sample.....	100
Light-colored limestone predominates, although there is some limestone of a brownish color. Thin, flat foraminifera, much broken up by the drill, are present.....	150
Chiefly a brown limestone, some of it powdered fine. Echinoderm and small, round foraminifera; also flat foraminifera.....	180
Dark-colored material. Contains a good deal of clay, which shrinks and breaks on drying, and is colored black by organic matter. With the clay is found fragments of limestone rock.....	185
Brown limestone. Some echinoderm spines and flat, thin foraminifera.....	250
Light-colored limestone. Shell fragments.....	325
Light-colored limestone. Occasional foraminifera; otherwise few fossils	400- 600
Light-colored granular limestone. Salty water. Bryozoan. Nummulites-like foraminifera. Small sea urchin.....	700
Finely powdered limestone, perhaps somewhat water sorted in collecting. Few fossils, altho contains some foraminifera as preceding sample...	800
Finely powdered light colored limestone, water sorted when collected (settlings from side of ditch).....	900
The rock at this depth differs from that which lies above in that it is more completely silicified. It is a limestone, altho much of the limestone has been changed to silica. The limestone is light colored, the altered, silicified rock is opaque and has a glassy or chalcedony-like appearance. The sample contains few fossils aside from foraminifera as in the preceding sample.....	920
Limestone similar to the preceding or perhaps more thoroughly silicified. The opaque or slightly brownish colored rock predominates, and there is but little of the light-colored limestone rock. The only fossil observed is the small foraminifera which, in this sample, is particularly abundant.....	940
Same rock, same character and contains same foraminifera as the preceding sample.....	950
This sample for the most part is the same silicified rock and contains the same small foraminifera as the preceding sample. It contains, however, a little more of the light-colored limestone in proportion to the flint.....	953
Light-colored limestone, including a small amount of silicified rock. Aside from occasional small foraminifera, no fossils observed.....	960
Light-colored limestone. Small foraminifera present. No other fossils observed.....	970
Light-colored limestone, including some silicified rock. Foraminifera present.....	-980

¹Fla. Geol. Surv., 12th Ann. Rept., pp. 82-84, 1919.

	<i>Depth in feet.</i>
Light-colored limestone, including considerable silicified rock. Echinoderm spines and small foraminifera present.....	990
Light-colored limestone and silicified rock. Small foraminifera very numerous. (A new casing put in showed the actual depth to this level to be 1016 feet. The depth of samples which follow are for the corrected depth)	1000
Light-colored limestone and flint fragments and small foraminifera.....	1050
Light-colored limestone and pieces of opaque flint. Foraminifera numerous	1100
Light-colored limestone, including some flint. Small foraminifera.....	1135
Light-colored limestone, including some flint. Fossils present include foraminifera	1150
Limestone powdered fine. Fossils present include foraminifera.....	1200
Limestone powdered fine by the drill; small, flat foraminifera present.....	1287
Limestone powdered fine. Foraminifera present.....	1322
Light-colored limestone. Small foraminifera present.....	1400
Light-colored limestone, very finely powdered. No fossils observed.....	1450
Light-colored, rather soft lime rock. No fossils observed.....	1500
Light-colored limestone and opaque flint.....	1559
Light-colored limestone, including a good deal of opaque flint. No fossils observed	1576
Essentially the same as the preceding, including considerable quantity of flint. No fossils observed.....	1586
Light-colored limestone, including some flint. No fossils observed.....	1596

Log of Well Below 1,559 as Made Up by J. A. Cushman, Twelfth Annual Report, Page 83

	<i>Depth in feet.</i>
Similar, but with flinty chips at 1,600 feet, with large rusty iron flakes as though casing has been put down at this point or new drilling started	1559-1661
Light-colored, crystalline limestone, with a few casts of foraminifera	1700-1800
Similar material, with bluish fragments similar to some seen at 1,450 feet, probably from above	1800-1900
Similar	1900-1922
Mostly rusted iron flakes from casing.....	1922
Similar to 1900 feet.....	1925-1993
Hard, compact, crystalline limestone. No foraminifera.....	1995
No identifiable foraminifera	2000-2100
Peculiar fibrous, oily material, with light-colored material from above...	2135-2153

The fossils from these samples have been studied by Cushman, who regards the formation below 325 feet as of Lower Cretaceous Age.¹ Showings of oil were reported in this well.

GEOLOGIC SUBDIVISIONS IN PENINSULAR FLORIDA

LIVE OAK AREA

Investigations made by the United States Geological Survey in cooperation with the Florida Geological Survey indicate a more or less well-marked dome in the vicinity of Live Oak in Suwannee County. In

¹Fla. Geol. Surv., 12th Ann. Rept., p. 82, 1919.

the surface drainage this dome is believed to be indicated by the very pronounced westward bend in the Suwannee River. In Hamilton County, north of Live Oak, the Alum Bluff formation as seen in the banks of the Suwannee River lies at a lower level than near Live Oak. The data on which this area is determined as structurally a dome has been presented in the Thirteenth Annual Report of the Florida Survey, page 16, 1921.

OCALA AREA

A considerable area in central peninsular Florida consisting of Alachua, Marion, Levy and Sumter Counties, and a part of Columbia and Union Counties is included in a large structural dome or geanticline. In this area, which may be known as the Ocala Area, the Oligocene apparently is wanting, and the Alum Bluff Miocene which formerly covered all or nearly all of the area now is found only locally, often existing as remnants. The Eocene limestones are either at the surface in this area or are sufficiently near the surface to be occasionally exposed in sinks, so that the Eocene may be regarded as the country rock of this part of the state.

As already noted, wells in this area will start either in the Alum Bluff, Miocene, or in the Eocene. The thickness of the Tertiary formations is very moderate. The Alum Bluff may in places attain a thickness of as much as 100 feet, while the Eocene, according to the records which we now have, rarely exceeds 100 or 200 feet in thickness. Next beneath the Eocene, according to Cushman, is the Lower Cretaceous, the Upper Cretaceous being absent. No well as yet drilled in this area is known certainly to have passed through the Cretaceous.

The following record of a deep well in Sumter County indicates the character and probable age of the formations in central peninsular Florida to a depth of 3,090 feet:

Well of Dundee Petroleum Company, Sec. 36, T. 20 S., R. 22 E., about four miles northeast of Bushnell, Sumter County. Samples collected by L. W. Hudson, driller, submitted by H. B. Goodrich, Geologist. Well begun July, 1917, completed February, 1918. From the surface to 380 feet no samples were taken. This interval, however, consists chiefly or entirely of limestones.

	<i>Depth in feet.</i>
Limestone, no fossils observed; nearly white, breaks into angular fragments	380
Limestone, apparently no fossils, except one echinoid; nearly white, not crystallized	385

	<i>Depth in feet.</i>
Limestone, apparently no fossils; light brown, apparently small crystals	390
Limestone, nearly white; not crystallized; no fossils	400
Limestone, nearly white; for the most part not crystallized, although one sample (brown crystal)	405
Limestone, nearly white; for the most part not crystallized; angular fragments	410
Limestone, very light; from somewhat crystallized small fragments	415
Limestone, very light; from somewhat crystallized small fragments	420
Limestone, whiter; not crystallized; no fossils	425
Limestone, whiter; not crystallized; some fossils as casts	430
Limestone, nearly white or very light brown (second sample pure white)	435
Limestone, nearly white or very light brown (second fragment of fossils)	440
Limestone, white; not crystallized; no fossils	445
Limestone (not noted on re-examination)	450
Limestone, white; not crystallized; no fossils	455
Limestone, white; not crystallized; fossils as casts	460
Limestone, white; not crystallized; no fossils	465
Limestone, very light brown; not crystallized; no fossils	470
Limestone, very light brown	475
Limestone, white; non-crystallized; no fossils	480
Brown limestone, light brown; angular fragments	490
Light-colored limestone; brownish angular fragments	495
Limestone, brown in color, differing from that above which was light colored; light-brown angular fragments; fossils as casts; crystallized	505
Limestone, brown in color; hard rock, powdered fine	545
Limestone, brown in color; hard rock, powdered fine; small crystals	550
Limestone, light brown; hard rock, powdered fine; small crystals	556
Limestone, light brown	562
Limestone, light brown	568
Limestone, brown in color; hard rock, powdered fine; few crystals	573
Limestone, brown in color; light brown, powdered fine	579
Limestone, brown in color; finely crystallized	594
Limestone, brown in color; finely crystallized	599
Limestone, brown in color; probably very small crystals	604
Limestone, brown in color; probably very small crystals	609
Limestone, brown in color; apparently very finely crystallized	628
Limestone, brown in color; apparently very finely crystallized	632
Limestone, brown in color; light brown	637
Limestone, brown in color; light brown; finely crystallized	642
Limestone, brown in color; finely crystallized	654
Limestone, brown in color; breaks into angular fragments; perhaps crystallized	664
Limestone, brown in color; hard rock, powdered fine; fine crystals	669
Limestone, brown in color; hard rock, powdered fine; fine crystals	674
Limestone, brown in color; probably some crystals	679
Limestone, brown; sample contains also dark carbonaceous fragments; small crystals	684
Limestone, brown; sample contains also dark carbonaceous fragments and pieces of chalcedony; small crystals; no fossils	689
Limestone, brown in color; hard rock, powdered fine; crystallized	694
Limestone, brown in color; small crystals	700
Limestone, brown in color	706
Limestone, brown in color; probably small crystals	711
Limestone, light brown in color; rather finely powdered; some crystals	716
Limestone, light brown in color; some small gypsum crystals	727

Depth in feet.

Limestone, light brown in color; breaks moderately fine; some gypsum crystals	742
Limestone, light brown in color; very light brown; perhaps some crystals	750
Limestone, light brown in color	756
Limestone, light brown in color; somewhat crystallized	762
Limestone, light brown in color; finely crystallized and has gypsum	768
Light-colored limestone; nearly white; not crystallized; no fossils	774
Light-colored limestone; white; not crystallized; no fossils	780
Brown limestone, finely powdered; small crystals	791
Brown limestone, finely powdered; small crystals	814
Brown limestone, powdered fine	820
Brown limestone; very light brown; no fossils	825
Brown limestone; very light brown, powdered fine; no fossils	836
Brown limestone; white or very light brown; no fossils	843
Brown limestone; very light brown; no fossils; apparently not crystallized	856
Brown limestone; medium light brown; no fossils; somewhat crystallized	867
Dark brown limestone; finely crystallized	877
Dark brown limestone; very small crystals	890
Dark brown limestone; small crystals	896
Dark brown limestone; small crystals	902
Brown-colored limestone with inclusions of black carbonaceous pieces; perhaps mostly crystallized	907
Brown limestone; finely powdered; small crystals	915
Brown limestone (not noted on second examination)	980
Brown limestone; finely powdered; small crystals	1005
Brown limestone; powdered fine; many small crystals	1008
Brown limestone; rather dark brown; powdered moderately fine; crystals	1016
Brown limestone; light brown; powdered moderately fine; perhaps crystals	1027
Light-colored limestone, with small fossils, almost dull gray	1052
Light-colored limestone; white; no fossils seen	1057
Light-colored limestone; nearly white, although somewhat gray; many small fossils	1062
Light-colored limestone; sooty brown; many small fossils	1067
Light-colored limestone; sooty brown; many small fossils and small foraminifera	1072
Light-colored limestone; sooty brown; many small fossils and small foraminifera	1078
Light-colored limestone and pieces of charred wood; not crystallized; no fossils	1084
Light-colored limestone and pieces of charred wood; not crystallized; no fossils; charred wood or bituminous	1094
Light-colored limestone; white or nearly white; not crystallized	1095
Light-colored limestone; white; small foraminifera as at 1,084	1102
Light-colored limestone; white; not crystallized; no fossils	1107
Light-colored limestone; white; not crystallized; no fossils	1112
Light-colored limestone; white; not crystallized; fragments of fossils (?)	1117
Light-colored limestone; white, angular fragments; not crystallized; no fossils	1123
Light-colored limestone; white, angular fragments, rather coarse; non-crystallized foraminifera	1140

	<i>Depth in feet.</i>
Light-colored limestone; white, angular fragments; not crystallized; no fossils	1145
Light-colored limestone; pure white, angular; not crystallized; no fossils	1150
Light-colored limestone; white, angular fragments; not crystallized; no fossils	1170
Light-colored limestone; white, angular fragments; not or only partly crystallized (foraminifera and bryozoa)	1240
Light-colored limestone; white, angular fragments; pecten; foraminifera; not crystallized	1281
Light-colored limestone; white rock and crystallized from rock mixed	1305
Light-colored limestone; light brown; finely powdered; small crystals	1331
Light-colored limestone; nearly white; break coarse; bryozoa; not crystallized	1421
Light-colored limestone; nearly white; break coarse; no fossils	1430
Light-colored limestone; nearly white; break coarse; no fossils	1450
Limestone, hard rock; powdered fine; brownish; very small crystals	1458
Limestone, light brown; powdered fine	1490
Limestone; light brown; powdered fine; brownish; some crystals	1495
Limestone; light brown; small crystals; finely powdered	1500
Limestone; light brown; angular fragments and crystals	1510
Limestone, including pieces of blue lime rock; not crystallized; no foraminifera	1520
Limestone, including many pieces of blue lime rock, apparently not crystallized	1525
Limestone; bluish cast; mostly non-crystalline; spines of sea urchins	1530
Limestone (second sample), including pieces of carbonaceous material; no fossils	1540
Limestone; light brown; partly crystalline	1540
Limestone; light brown; powdered fine; some crystals	1550
Limestone; nearly white; not crystallized; angular fragments; bryozoan	1575
Limestone; nearly white; hard rock, almost crystallized; angular fragments; no fossils	1582
Limestone; dark brown; finely powdered; small crystals	1620
Limestone; light brown; small crystals; very finely powdered	1669
Limestone; dark brown; more or less crystallized	1670
Limestone; powdered fine; brown; probably small crystals	1680
Limestone; powdered fine; brown; small crystals	1690
Samples Examined January, 1918	
Light-colored limestone; slightly brownish; breaks into angular fragments	1692
Limestone; brownish in color; powdered fine; small crystals	1698
Limestone; brown; breaks into irregular fragments; granular	1703
Brown limestone; mostly finely powdered by the drill	1708
Very finely powdered hard limestone	1750
Record wanting, drillings going away in a crevice	1787
Brown limestone	1845
Blue limestone	1865
Brown limestone; several samples	1900
Record wanting, cuttings going away into a crevice	2005
Brown limestone	2070
Light-colored limestone	2075
Brown limestone	2080
Light-colored limestone	2085
Brown limestone	2120
Light-colored limestone	2140
Limestone, finely powdered	2150

	<i>Depth in feet.</i>
Light-colored, finely powdered limestone.....	2240
Slightly brownish limestone.....	2370
White limestone	2390
Salt water	2405
White limestone	2410
Somewhat chalky, light colored limestone.....	2590
Dark limestone	2680
Light-colored limestone	2700-3090

The first samples obtained from this well were at a depth of 380 feet, and from that depth, according to Cushman (Twelfth Annual Report, page 89), to the bottom of the well is probably Lower Cretaceous.

BROOKSVILLE AREA

Somewhat detached from the Ocala Area just described is a smaller area lying to the west and including Citrus and Hernando Counties and a part of Pasco County. This area is topographically high and is separated from the Ocala Area by the Withlacoochee Valley. The formations at the surface include remnants of the Alum Bluff, Miocene, and occasional exposures of the underlying Eocene. Toward the southern part of the area, Oligocene limestones come into the section.

The only deep well drilled in this area is one near Crystal River in Citrus County which reached a depth of 1,900 feet and obtained flowing salt water. No log of this well has been preserved.

JACKSONVILLE AREA

The underground conditions in the northeastern part of Florida are known from wells at Jacksonville and also at Fernandina and in the Lower St. Johns Valley. In this part of the state the Eocene formations that are at the surface in central Florida drop to a level of about 500 feet below the surface. The formations drilled into at Jacksonville include Miocene or later, Eocene and Cretaceous.

*Record of City Water Well at Jacksonville**

	<i>Depth in feet.</i>
Filled ground and sand.....	0 - 15
Sand with some clay.....	15 - 33
Sandy limestone, yellowish or light buff in color.....	33 - 37
Light-colored clayey marl	37 - 70
Blue, sticky clay with black phosphatic pebbles.....	70 -100

*Fla. Geol. Surv., 5th Ann. Rept., pp. 177-178, 1913.

Depth in feet.

Marls, usually green or olive green in color, containing variable amount of sand, and clay. Black phosphatic pebbles, together with some shell fragments occur throughout the marl. Occasional thin layers of light-colored limestone are reported within this interval. First flow of water at 270 feet, 5 gallons per minute	100	-320
Buff clay, resembling fuller's earth, mixed as seen in the sample with green sandy marl	320	-340
Greenish and sandy, clayey marl	340	-390
Indurated sands or sandstones	390	-396
Greenish sandy marls	396	-415
Light-colored limestone	415	-420
Greenish calcareous sandy clay	420	-434
Dark-colored hard sand rock	434	-435
Olive green calcareous sandy clay	435	-455
Light sandy marl	455	-455½
Green sandy marl	455½	-462
Dark sandy clay	462	-490
Very hard dark or gray sand rock	490	-493
Silicified and very hard shell rock, with siliceous phosphatic pebbles. After passing through this rock the flow is increased to 112 gallons per minute, temperature 71 degrees F.	493	-498
Light-colored marl	498	-500
Hard rock	500	-506
Light gray, sandy, calcareous rock, with black phosphatic pebbles	506	-510
Light-colored fossiliferous limestone (Vicksburg). Upon reaching this formation, the flow is increased to 200 gallons per minute. At 625 to 635 feet the harder stratum was drilled through, which flowed 500 gallons per minute, temperature 74 degrees F. At 680 feet the water pressure measured, as shown by the gauge, 12 pounds	510	-680
Limestone, prevailing brownish in color and, as a rule, harder than above. Occasional thin layers of marl and shell. Slight increase of flow at 780; water pressure at 900 feet, 15 pounds; flow about 900 gallons per minute; temperature, 74 degrees F.	680	-900
Limestone similar in character to above, but as a rule not so hard. Flow at 980 feet, 1,500 to 2,000 gallons per minute	900	-980

The Eocene is entered in this well at or near a depth of 500 feet and the well terminates in the Lower Cretaceous.

DAYTONA AREA

In several counties on the eastern side of central peninsular Florida, the Eocene limestones are covered with Miocene and later formations to a depth of from 100 to 200 feet. The counties included within this area are St. Johns, Flagler, Putnam, Volusia, Seminole, Orange, Brevard and parts of Lake and Marion Counties. At Sanford, on the St. Johns River, and at New Smyrna on the Atlantic coast, the Eocene lies at a depth approximating 100 feet; elsewhere the depth to the Eocene is between 100 and 200 feet.

Following is the log of a well at New Smyrna, indicating the character of the formations at this place to a depth of 1,022 feet. The Eocene is probably reached in this well at 105 feet. Whether or not the well enters the Cretaceous and at what depth is not determined.

*Record of Samples From City Well at New Smyrna**

	<i>Depth in feet.</i>
Greenish, sandy, calcareous and phosphatic rock, some sharks' teeth and fragments of shell.....	93- 105
Sample containing a greenish rock and some fragments of white limestone.....	105
Pure white granular, porous limestone.....	105
Light-colored granular limestone.....	181
Limestone, slightly brownish cast.....	265
Limestone, mostly light brown in color.....	285- 296
Limestone, mostly light brown in color.....	290
Brown limestone.....	1022

KISSIMMEE AREA

The conditions to be expected in drilling in the Kissimmee Valley and near Lake Okeechobee are indicated by wells drilled near Kissimmee (see Osceola County) and at Lake Okeechobee. In this part of the state the wells start in the Pleistocene. Miocene fossils, according to Cushman, are recognized in the Okeechobee well from 87 to 500 feet.

Well samples from the well of the Okeechobee Company, Okeechobee, Florida. Well located on lot 5, block 134, approximately 34 feet above sea, and about 14 feet above the level of Lake Okeechobee; 10-inch pipe rested at 150 feet; 8-inch pipe rested at 307 feet; 6-inch pipe rested at 484 feet. Total depth of well, 810 feet.†

	<i>Depth in feet.</i>
Fine gray sand and soil.....	0- 2
Fine sand, chocolate colored, some of it indurated with organic matter, ordinary hard pan.....	2- 12
Gray or slightly brownish, indurated sand (not marl).....	12- 15
Gray sands.....	15- 38
The sample preserved consists chiefly of black clay containing considerable sand, one fragment of shell, but aside from this no indication of marl.....	38- 41
Sandy shell marl, shells much broken.....	41- 56
Shell marl, pecten, barnacles, etc., marine shallow-water marl.....	56- 62
Gray sandy marl with broken shell, similar to No. 6.....	62- 65
Coarse, clear grain sand and broken shell. Ostrea, turritella, bryozoa.....	65- 81
Sandy marl with broken shell. Pecten.....	81- 87
Very sandy, olive-colored marl.....	87- 94
Light gray incoherent sand.....	94-139

*Fla. Geol. Surv., 12th Ann. Rept., p. 125, 1919. The total depth of this well is 1,440 feet. Information by letter from the contractor, E. A. Durst, Jacksonville, Fla., under date of Nov. 19, 1919.

†Fla. Geol. Surv., 12th Ann. Rept., pp. 126-127, 1919.

	<i>Depth in feet.</i>
Light-colored, sandy marl with shell fragments. Pecten. Occasional phosphate pebbles, black and shiny.....	139-158
Olive green sand or very sandy marl.....	158-175
Olive green clay with black, smooth, shiny pebbles, phosphatic.....	175-212
Dark-colored, very sandy marl or calcareous sands, some broken shells.....	212-240
Olive green, very sandy and calcareous clays, or clayey sands.....	240-245
Very sandy, dark-colored marl with shell fragments.....	245-276
Calcareous and very sandy clay or clayey sand.....	276-300
Dark-colored sand, broken rock and shell fragments.....	300-380
Very sandy, dark-colored marl, sand grains small.....	380-403
Light-colored sand, broken rock and shell fragments.....	403-458
Dark clay and broken shells.....	458-468
Drab-colored clay	468-500
White limestone rock with fragments of echinoderm spines.....	500-510
Chiefly sand	510-608
White limestone with many fossils.....	608-615
Limestone, powdered fine by the drill.....	615-775

TAMPA AREA

The Gulf coast of south Florida west of the Peace River, including Hillsborough, Pinellas, Polk, Manatee and Sarasota Counties, is an area in which Miocene formations are either at the surface or are covered by a thin veneer of Pliocene and Pleistocene. In the northern part of this area, west and north of Tampa, the Oligocene comes to the surface on the coast and in stream beds.

The formations entered in drilling in this area include the Pliocene, and Pleistocene if present, the Miocene, Oligocene, Eocene and Lower Cretaceous. A well drilled at Tiger Bay will serve to illustrate the kind of sediments to be expected in drilling in this part of the state.

*Description of Samples From Well No. 3 of the Palmetto Phosphate Company, Tiger Bay, Florida**

	<i>Depth in feet.</i>
The rock at this depth is a light-colored phosphatic marl or limestone. In texture and appearance it is like the marl which lies beneath the land pebble phosphates. The phosphate is in the form of smooth, rounded, black, brown, and white pebbles. While this is the prevailing material of the sample, at least one fragment consists of clear-grained quartz, held together by a phosphatic or calcareous cement and resembling Alum Bluff sands. Acid test showed this piece to be but slightly, if at all, calcareous. There are also some fragments of dark blue, hard rock which effervesce but slightly in acid. No fossils were seen in this sample.....	73
This is also a phosphatic marl or limestone. It is similar to the 73-foot sample except that it is lighter in color, being light gray or nearly white. The phosphatic pebbles are mostly black in color, the black	

*Fla. Geol. Surv., 7th Ann. Rept., pp. 45-48, 1915.

Depth in feet.

pebble in the light-colored marl giving a grayish cast to the rock. The hard, blue rock that effervesces scarcely at all in acid is rather more abundant in this than in the preceding sample. This hard rock also contains black phosphate pebbles, and it is probable that it is merely a silicified phase of the marl. Some casts of fossils, but no determinable specimens. A considerable amount of clear-grained silicious sand is seen among the finer material.	85
The material at this depth is also calcareous and phosphatic. The phosphate pebbles are black or brown and are smooth and rounded. The rock contains numerous small cavities, giving it a porous appearance. Only one fossil is seen, this being part of a small gastropod.	150
A phosphatic limestone or marl, with some fossil gastropods and bivalves preserved as casts. The rock at this depth is in general similar to the 150-foot sample. The fossils seem more abundant, perhaps, because the sample is larger. The phosphate pebbles are black, brown, and white in color.	160
Compact brown, phosphatic limestone. The phosphate pebbles are not abundant in this limestone and are in the form of small, black pebbles imbedded in the rock. While the rock is prevailingly compact, some porous fragments are seen. A few broken fossils preserved as casts.	180
This sample includes compact phosphatic limestone, with about equal admixture of pure white, silicious sand. Whether the sand is from a sand stratum or from the six-inch cavity found at this depth, or possibly accidentally mixed from the surface, is not known.	190
A sandy, calcareous and phosphatic clay. In water this material falls to pieces and becomes liquid. In acid it effervesces. The sand is in the form of clear-grained silica. The phosphate is mostly in the form of small, black pebbles. Material is light colored when dry, although slightly bluish when wet.	195
This material is similar to that at 195 feet, although there is perhaps less phosphate, and the sand is perhaps smaller grained.	200
A gray, sandy, phosphatic limestone. The calcareous material seems to predominate, although the rock is rather sandy. The sand grains are small and well rounded. The phosphate is in the form of very minute, dark specks, and the rock possibly also has a phosphatic cement. No fossils seen	205
A gray, sandy, phosphatic limestone. The calcareous material seems to predominate, although the rock is rather sandy, the sand grains are small and well rounded. The phosphate is in the form of very minute, dark specks, and the rock possibly also has a phosphatic cement. No fossils seen in this material, except some imperfect casts in fragments of a porous limestone, which may have fallen down from a higher stratum. These porous pieces occur also in the sample at 205 feet.	240
Light-colored, sandy and phosphatic limestone. The sand grains are clear silica. The phosphate pebbles are dark colored. A few fragments of casts of fossils. This rock is not materially different from that at 205 and 240 feet, except that it is lighter in color.	250
Bluish gray, sandy, phosphatic limestone, together with loose calcareous sand, probably representing the ground-up rock. No fossils seen except echinoderm spines.	255
Gray or blue, calcareous, sandy, phosphatic clay. No fossils. This material is similar to that at 200 feet.	255-260
Bluish gray, sandy, phosphatic limestone, together with loose calcareous sand, probably representing the ground-up rock. No fossils seen except echinoderm spines.	265

Depth in feet.

Light-colored, sandy, phosphatic limestone. This is very similar to the rock above the blue clay. A few fossils, including fragments of pecten. Also one flattened water-worn pebble of the same material as the rock above.....	272
The greater part of the material of this sample is the bluish gray, sandy, phosphatic limestone similar to that already described. With this is found a light-colored, compact limestone, very slightly phosphatic, as shown by test. The sample also contains several pieces of red iron ore. Of fossils, only a few fragments were seen.....	275
Light-colored, phosphatic and slightly sandy marl or limestone. The phosphate is in the form of smooth, dark pebbles imbedded in the marl. The rock is fossiliferous, although the fossils are badly broken.....	320
Light-colored, phosphatic marl or limestone, more or less sandy. One small fragment of chalcedony holding cast of shell. A few fossils, mostly broken bivalves and gastropods. The sample includes some bluish gray, sandy, phosphatic limestone.....	350
Light-colored, phosphatic, sandy marl; also some bluish gray, sandy, phosphatic marl or limestone. Some broken fossils are included.....	360
Light-colored, finely powdered marl or limestone. Fragments of echinoderm spines are present and other small or broken fossils. A few phosphatic pebbles are seen, being black and shiny in appearance. A clear-grained quartz sand occurs sparingly. This material is less phosphatic than that which lies above and resembles the Chattahoochee limestone as seen at Newland Spring, near Falmouth, in Suwannee County, and near Bass, in Columbia County. Test showed this powdered material to contain a small amount of phosphate.....	400
Light-colored, finely powdered marl or limestone. Fragments of echinoderm spines are seen, and also other small fossils, including a few bryozoa. This material is similar to that at 400 feet, although there seem to be no phosphatic pebbles and little, if any, sand.....	410
Light-colored, nearly white limestone, not so finely powdered as the preceding two samples. Fragments of broken shells are abundant. Bryozoa are numerous. Some foraminifera are present, the most common being orbitoides. This limestone is, with little doubt, the Ocala. Test shows it to be not phosphatic.....	420
The limestone at this depth is practically the same as that at 420 feet. It is light-colored or nearly white, fragments of broken shell are abundant, among which pecten is recognized. Small foraminifera are numerous, and there are also broken pieces of larger specimens. Bryozoa are present.....	450
Foraminifera abundant, chiefly orbitoides, including large specimens, most of which are broken by the drill.....	500
Foraminifera abundant. The material is similar to that at 500 feet.....	550
At this depth foraminifera are abundant. The predominating form is nummulites. Orbitoides present, but not abundant. The sample includes also some pieces of a soft, granular marl.....	600
Limestone, probably hard and compact, the sample being finely powdered by the drill. Both nummulites and orbitoides are present, although only the small specimens escaped being powdered by the drill. This compact limestone has a slightly brownish cast.....	630
Hard, compact limestone with brownish cast, powdered exceedingly fine by the drill. Few fossils escaped being powdered up, although some foraminifera and bryozoa are present.....	636
This sample shows a mixture of finely powdered material with brownish cast, together with coarser material from a softer rock. With the coarser material is included some small pieces of bluish-colored chert. Foraminifera are present.....	650

	<i>Depth in feet.</i>
A limestone, breaking into coarse fragments. The predominating fossil is a small, flat echinoderm, the internal cavity of which is, in most cases, filled with calcite crystals. Foraminifera are also present, although not numerous.....	665
A compact limestone with slightly brownish cast. The same small, flat echinoderm is present, although broken up by the drill, and is not abundant. Foraminifera are present, although not abundant.....	670
A brown limestone, rather hard but not very compact. Few if any fossils are preserved. It is probable that the minute fossils in the rock have dissolved out and the cavity partially refilled by calcite crystals. This gives the rock a porous and partially crystallized appearance and causes it to break into medium coarse fragments by the drill.....	680
The material is chiefly light brown or grayish brown, porous limestone, partially crystallized, the fossils having been destroyed. With this is included light-colored rock	690
This sample consists chiefly of soft, white limestone, in which is included a few foraminifera. A limited amount of the harder, brownish rock from the stratum above is present.....	710
A light-colored, rather hard, although porous, limestone which seems to be made up of a mass of broken shells and other fragments of fossils. One small flat echinoderm present, although broken.....	720
White granular limestone. Fossils not numerous, although a few foraminifera are seen; also broken pieces of a small flat echinoderm.....	740
Grayish brown limestone, rather hard and partly crystallized. A few fossils, including a small gastropod.....	760
Grayish brown limestone, rather hard and partly crystallized. Few, if any, fossils	770
The greater part of the material of this sample is brown or grayish brown powdered up by the drill medium fine. With this are several large pieces of ground rock which consists almost entirely of a mass of small calcite crystals. The sample contains also some light-colored material, including a few foraminifera.....	790
The material of this sample is similar to that of the last. The large fragments consist chiefly of a mass of small calcite crystals, the mass being brown in color	800
The rock at this depth is not unlike that at 800 feet, although it is darker in color, being very dark brown; somewhat compact and partly crystallized	814
A light-colored limestone which powders up medium fine in drilling. Foraminifera present	820
A light-colored limestone which powders up medium fine in drilling. Foraminifera present, although not abundant.....	830
The greater part of this sample is white and rather soft limestone; there are also some pieces of a white limestone consisting chiefly of broken fragments. With this are some dark-colored pieces which probably scaled off of the side of the cavity. A small flat echinoderm is present	838

Description of samples of another well at this locality has been given in the Seventh Annual Report of the Florida Survey, page 49.* In this

*Fla. Geol. Surv., 7th Ann. Rept., p. 49, 1915. Description of samples from well of Palmetto Phosphate Company, near pit No. 1, about $2\frac{3}{4}$ miles northwest of Tiger Bay.

well the Ocala limestone, according to Cushman, lies below 350 feet, and from 550 to 770 the formations are of Lower Cretaceous age.

FORT MYERS AREA.

The Ft. Myers area may be regarded as including De Soto, Hardee, Highlands, Charlotte, Glades and Lee Counties. The surface formations in the northern part of this area are chiefly Pliocene shell marls and in the southern and eastern parts of the area Pleistocene shell marl and limestone.

A deep well was drilled at Ft. Myers in 1914, from which a representative set of samples was obtained. This well reached a total depth of 950 feet.*

Description of samples from the city well, Ft. Myers, Florida; drilled, 1914; driller, Ohio Well Drilling Company, Jacksonville, Florida. Size, 10 to 8 inches; casing 10-inch, 14 feet; 8-inch, 203 feet; principal water supply 875 feet; flowing, yields 650 gallons per minute; depth, 950 feet; in charge of drilling, G. P. Peppard.

	<i>Depth in feet.</i>
Light-colored limestone with fragments of fossils, also some sand and dark, shiny phosphate pebble. Fossils include bryozoa, broken shell fragments, etc.	200
Much the same rock. Shark's tooth, some phosphate pebble, broken shells, some echinoderm spines and many bryozoa.....	210
Similar light-colored limestone. Some fine, black phosphate pebble imbedded in the rock.....	220
Similar light-colored limestone	230
Similar light limestone consisting of broken shell fragments, together with fragments of rock containing minute black phosphate pebble.....	280
Similar light-colored limestone consisting of broken fragments of different shells, together with some pieces of hard, dark-colored rock.....	300
Similar light-colored limestone consisting of shell fragments.....	320
A similar light-colored limestone containing also small shiny black phosphate pebbles.....	360
Similar light-colored limestone with an abundance of small shiny black phosphate pebbles	340
Similar light-colored limestone consisting of a mass of broken shell fragments, rather more finely broken up than the preceding. Phosphate pebbles somewhat less abundant than in last sample.....	380
Similar light-colored limestone consisting of a mass of shell fragments broken up finely	400
Similar light-colored limestone, some phosphate pebble as in preceding...	420
Similar light-colored limestone, including phosphate pebble, also one small oyster shell	440
Similar light-colored limestone, although not so finely broken up and including pieces of rock with the small phosphate pebbles imbedded.....	460
Buff calcareous clay, some phosphate pebble and some shell fragments.....	480

*Fla. Geol. Surv., 7th Ann. Rept., pp. 51-52, 1915.

	<i>Depth in feet.</i>
Light-colored limestone consisting of shell fragments with an abundance of black phosphate pebble and with small fragments of the sandy marl with slightly green shade of color.....	500
A somewhat harder limestone, containing, however, phosphate pebble.....	520
Limestone similar to that at 520. This limestone is not so light in color and does not contain so many shell fragments as the limestone above 320 feet	540
Very fine, siliceous and calcareous sand containing minute black phosphate pebble	600
Same as 600	640
Similar finely powdered material containing, however, less quartz sand...	680
Limestone with slightly brownish color and finely powdered by the drill...	720
Finely powdered calcareous material similar to that at 600 feet.....	760
Light-colored limestone consisting of a mass of broken fossils.....	800
Same as at 800 feet.....	840
Same as at 800 feet.....	880
Finely powdered rock including fine quartz sand, much like that at 600 feet.....	900
Limestone consisting of a mass of broken fossils.....	950

MIAMI AREA

A well drilled at Miami, and recorded under the discussion of Dade County, will serve to illustrate drilling conditions as found on the Atlantic Coast of southern Florida. In this part of the state the regional dip of the formations is to the southeast. Hence, in passing to the north and west any given formation may be expected at a somewhat lesser depth than at Miami.

Following is the log of a well drilled at Palm Beach, about sixty-five miles north of Miami:¹

Log of Well of C. I. Craigin, Two and a Quarter Miles North of Palm Beach. Well Drilled 1889-1890 by J. A. Durst

	<i>Depth in feet.</i>
Surface soil	0 - 5
Rock	5 - 7
First sand	7 - 8
Mostly fine coquina rock.....	8 - 36
Quicksand and sharp pieces of stone.....	36 - 57.2
First really hard rock.....	57.2 - 58
Coquina, alternating with sandy strata.....	58 - 76.10
Hard rock	76.10- 78
Very hard flint	78 - 78.6
Sand, white and solid, but not hard.....	78.6 - 84
Quicksand bed, mixed with bits of coarser material.....	84 - 96
Flint rock, thin	96 - 96.6
Fine sand	96.6 - 97
Quicksand bed	97 - 148

¹Fla. Geol. Surv., 5th Ann. Rept., pp. 274-276, 1913.

	<i>Depth in feet.</i>
Solid limestone.....	148 - 151
Soft gray limestone.....	151 - 169.6
Hard rock	169.6 - 170
Shell stratum	170 - 171
Very hard sandstone.....	171 - 171.3
Sandstone	171.3 - 175
Alternately hard and soft limestone.....	175 - 185
Straw colored sandstone.....	185 - 190
Drab-colored, solid sandstone, gradually deepening in its color to a final blue at 230 feet, with small delicate shells throughout.....	190 - 238
Bed of small dainty shells. Water level is 3 feet 4 inches below wooden curb	238 - 238.8
Very hard drilling, required to move casing in these alternations. Water level about 20 inches (near 242 feet). Very active quicksand	238.6 - 248
Took out loads of quicksand.....	248 - 250
Sand. Water in this sand ran slowly out of pipe at 3 feet 6 inches above ground	250 - 262
Coquina	262 - 263
Broken shell and sand, more shell (white and pulverized) the last few feet. Water level just above ground level.....	263 - 300
Rock. Water stands 2 feet 4 inches above curb in this stand	300 - 301.6
Brown clay, first seen in this well.....	301.6 - 303.6
Sand	303.6 - 310
Blue sandstone	310 - 312.4
Blue sand, shells and pieces of rotten sticks.....	312.4 - 312.10
Blue sandstone	312.10 - 315.2
Sand. Water in this sand stands 3 feet above wooden curb.....	315.2 - 320
Blue Sandstone	320 - 321
Fine shell and sand, coarser broken shell toward bottom.....	321 - 340
Rock	340 - 340.3
Coarse, broken shell, blue pebbles and pieces of coquina. Water 2 feet above curb, runs freely at 1 foot above.....	340.3 - 350
Yellow sandstone. Water 2 feet above curb.....	350 - 357
Broken shell, pebbles, pieces of coquina.....	357 - 359
Pulverized shell	359 - 373
Gray limestone, with some broken shell lying immediately beneath. Water stands 2 feet 4 inches above on penetrating this rock	373 - 374
Pulverized shell. Water stands at level of wooden curb.....	374 - 392
Alternations of rock and blue marl.....	392 - 400
Blue marl	400 - 409
Alternations of blue marl and sand which afforded the greatest flow to date and the first fresh water below 49 feet.....	409 - 432
Blue marl	432 - 507
Coquina	507 - 510
Proportion of sand in the marl increases very much.....	510 - 542
Quicksand, below casing; can not drill at all. Proportion of sand in the marl increases.....	542 - 571
Marly sand. Head of water from 9 to 11 feet above ground. Water rises so as to dribble from a height of 11½ feet.....	571 - 614
Quicksand bed	614 - 618
Rock	618 - 618.6
Sand or sandstone	618.6 - 640

	<i>Depth in feet.</i>	
Lighter colored and runs to greenish, marly sand all through here.		
At depth 678-688 more sand. Water from 690-700. Very many tiny spiral shells.....	640	- 707
Brown, coarse material	707	- 710
Sand with enough marl with it to give a green color to the slush as ejected	710	- 794.6
Loose sand, full of black specks and tiny bivalve and spiral shells	794.6	- 809
Blue marl, full of black specks.....	809	- 826
Sand	826	- 828
Sandstone	828	- 834
Very fine, tough clay, thoroughly impervious.....	834	- 839
Fine-grained coquina. Get dribble of water at depth of about 844 feet 4 inches; casing driven to depth of 846 feet; tight in rock	839	- 860
Solid, hard limestone	860	- 867
Fine clay, devoid of grit.....	867	- 874
Hard rock	874	- 876
Lots of black specks here.....	876	- 878
Clays, sandy, and lots of black specks. No water.....	878	- 902
Dark sand bed. Here the water supply is 115,000 gallons per diem	902	- 905
Thin block of stone 909 feet, about. This is the lowest sand bed with thin block of limestone at intervals. Water comes from between these thin flakes of limestone.....	905	- 917.6
Limestone	917.6	- 917.9
Coralline	917.9	- 923
Hard limestone rock at 923, solid rock nearly 39 feet.....	923	- 961
Gritty marl	961	- 973
Solid rock	973	- 990.6
Sandy marl, full of tiny spirals.....	990.6	-1009
Limestone	1009	-1012
Yellow sandstone	1012	-1023
Hard rock	1023	-1025
Rock, first of the regular water strata. Alternating hard and soft strata. Increase of water with depth. At depth of 1,042 feet, 270,000 gallons; 1,057 feet, 300,000 gallons; 1,075 feet, 350,000 gallons. Water strata found at frequent intervals.....	1025	-1088
Gray limestone	1088	-1110
Gray limestone, interspersed with water strata, but the flow increases but slightly. At 1,160 feet flow totals 400,000 gallons...	1110	-1116
Solid gray limestone	1116	-1174
Blue limestone	1174	-1175
All solid	1175	-1193
Blue limestone (?)	1193	-1195.6
Six inches water stratum.....	1195.6	-1196
Mostly gray limestone, with some hard, and some water strata. Flow increases but little.....	1196	-1212

It is probable that the Eocene in this well is entered at between 915 and 1,000 feet. (Darton, Am. Jour. Sci. XLI, p. 105, 1891.) The limestones beginning at 917.6 feet are probably Eocene.

KEY WEST AREA

Underground conditions on the Florida Keys and elsewhere in extreme southern Florida are known to a depth of 2,555 feet by wells

drilled at Marathon and at Key West. Of the Marathon well a very complete set of samples to 1,790 feet was obtained through the courtesy of the Florida East Coast Railway Company. The well at Key West is also represented by a partial set of samples.

Record of the well of the Florida East Coast Railway Company drilled at Marathon, on the Florida Keys, in 1918. This well was begun February, 1917, and completed to a total depth of 2,555 feet early in 1918.*

	<i>Depth in feet.</i>
Coralline limestone, very hard. Represented by nineteen samples.	
All hard limestone, mostly finely powdered by the drill.....	35- 179
Two samples. Very fine white sand, containing well-rounded, small grains of the mineral ilmenite.....	108- 274
Four samples. Sand, medium coarse, slightly greenish in color, includes small amounts of clay.....	305- 409
Very coarse sand, including some phosphate pebble. Two samples.....	412- 425
Two samples. Coarse, siliceous pebbles, including much pebble phosphate	427- 428
Four samples. Medium coarse sand, greenish in color.....	429- 471
Two samples. Coarse sand, including clay balls.....	427- 480
Medium coarse sand, mostly greenish in color, contains some clay fragments and some phosphate pebble. Seven samples.....	571- 584
Coarse sand with phosphate pebble. Three samples.....	584- 589
Porous white limestone, fossils preserved as casts.....	593
Coarse sand, including phosphate pebble. The material of this sample probably fell from above as the 10-inch casing had not yet been set...	598
Limestones. Numerous samples	601-1790

This well starts in Key Largo limestone, which is Pleistocene. According to Cushman Miocene is recognized from 180 to 412 or possibly to 585 feet; Oligocene from 589 to 984 feet or deeper, while Lower Cretaceous fossils are present from and below 1,248 feet.

DISCUSSION BY COUNTIES

ALACHUA COUNTY

Alachua County is in central peninsular Florida. The surface materials are in part those of the Alachua formation (Pliocene), the Alum Bluff formation (Miocene), and in part the Ocala formation (Eocene).

Numerous water wells in this county have been drilled to a depth of from 150 to 472 feet, terminating in water-bearing limestones.

*Fla. Geol. Surv., 12th Ann. Rept., p. 95, 1919. The total depth of this well is 2,555 feet. Information by letter from the contractor, E. A. Durst, Jacksonville, Fla., under date of November 19, 1919.

Following is a log of a well drilled by the Diamond Ice Company at Alachua:*

	<i>Depth in feet.</i>
Sand, brown	0- 7
Clay, soft, brown	7- 22
Limestone, soft, white	22- 80
Limestone, hard, gray	80-180
Limestone, hard, brownish white.....	180-220
Limestone, hard, gray, containing layers of blue flint.....	220-270

The surface materials at this locality to a depth of 22 feet probably represent the Alum Bluff formation or material residual from that formation. The underlying limestones probably represent the Ocala formation (Eocene). From the depth of the well it seems likely that formations older than Ocala limestones were reached.

BAKER COUNTY

Baker County, in the northeastern part of Florida, adjoining the Georgia-Florida state line, is one of the counties on which but few geologic data are available. The surface is moderately rolling except in the northern part, where the Okefinokee Swamp of Georgia extends into the county. The surface exposures in this county include red and yellow sandy clays and sands of undetermined age. Miocene and possibly some later formations underlie these surface materials. No deep wells have been drilled in this county. The Miocene and Eocene formations found exposed farther to the southwest will probably be found dipping to the north or northeast and passing under this county.

BAY COUNTY

Bay County is on the Gulf coast in West Florida. Miocene shell marls lie at the surface in the northern part of this county, and on the gulf coast the Upper Miocene probably lies at no great depth.¹

Following is the log of a well drilled about two miles across the bay from Panama City:

*From U. S. Geol. Surv., Water Supply Paper 319, 264, 1913.

¹In the 12th Annual Report of this Survey, p. 120, reference is made to the Alum Bluff Miocene being found in a well at Panama City from 30 to 60 feet from the surface. The Choctawhatchee formation (Upper Miocene) was intended and not the Alum Bluff formation, which is Lower Miocene.

Description of samples from well opposite Panama City, located in NW $\frac{1}{4}$ S. 23, T. 4 S., R. 14 W. Well drilled in 1911 and samples submitted by G. M. West, Panama City:

	<i>Depth in feet.</i>
Chiefly sand, with some shell fragments.....	1- 30
Sample preserved as representative of this interval is a dark-colored alum-tasting clay, apparently the same clay as exposed at Alum Bluff	30- 60
Chiefly gray sand marl. The sand grains are clear quartz held together by calcareous cement	60-100
Buff-colored, clayey marl; enough clay to become slippery when wet. One sample	100-200
Mixed sample, including a greenish, sandy marl and a light-colored cal- careous marl	200-300
Limestone	300-350
Gray, clayey marl. One sample.....	350-400
Sample at 400 feet is light-colored limestone.....	400-460
Sample reported from 460 feet is a smooth, rounded, black phosphate nodule. Probably dropped from above.....	460-470
Light-colored limestone	470

According to determinations made by Cushman, the Eocene is probably, although not certainly, reached in this well at 400 feet.

BRADFORD COUNTY

Bradford County lies south of Baker and Union Counties in north-east Florida. In the eastern part of the county is a pronounced topographical feature known as Trail Ridge. This ridge enters the county at the east side near the northeast corner, and continues southward, merging into the high lake region area in the southern part of the county. With little doubt, the maximum elevations of northeastern Florida (about 240 feet) are found on this ridge in the eastern part of Bradford County or the western part of Clay County.

In the northern part of Bradford County the surface exposures include clays, sandy clays and sands of undetermined age. The only deep well recorded in this county is at Starke, and of this well, which reached a depth of about 529 feet, unfortunately no adequate record exists. The topographically high area of Trail Ridge is suggestive of a structurally high area. However, in the absence of adequate exposures and of deep-well records, no conclusive evidence is obtained as to structure in this area.

BREVARD COUNTY

Brevard County is on the Atlantic coast of Florida. The surface formations include shell beds, marls and sands of Pleistocene age. The Plio-

cene and Miocene are probably present, although thin, as the Eocene is entered near the coast at a depth of from 190 to 220 feet. Some wells in this county have a depth of about 1,000 feet. (See page 40.) Following is a log of a well drilled on Melbourne Beach:

*Log of Well at Melbourne Beach**

	<i>Depth in feet.</i>
Surface sands and soil.....	0 - 3
Yellow sand	3 - 11
Coquina rock	11 - 21
Fine gray sand	21 - 51
Shell and sand	51 - 56
Hard shell rock	56 -119
Greenish clay	119 -173
Dark-colored rock, sharks' teeth.....	173 -173½
Greenish clay	173½-174¼
Dark-colored rock, sharks' teeth.....	174¼-175
Greenish clay	175 -221
Eocene limestone. Increase of flow with depth. A pressure of 17½ pounds at this depth was shown by the gauge March 15, 1910.	
Mild sulphur water	221 -318

BROWARD COUNTY

Broward County is on the Atlantic coast, in southern Florida. The surface formations are of Pleistocene age, the western part of the county being within the Everglades. No records of deep wells have been obtained in this county.

CALHOUN COUNTY

Calhoun County lies west of the Apalachicola River and extends south to the Gulf of Mexico. Near the north line of the county, on the Chipola and Apalachicola Rivers, the Chattahoochee formation is exposed at the surface. Farther to the south the Lower and Upper Miocene shell marls come into the section. The Lower Miocene shell marls are seen at Bailey's Ferry, on the Chipola River, while the Upper Miocene is found at Abe's Spring, farther down the same river, the dip of the formations being toward the Gulf. In the southern half of the county the exposures consist of sandy clays and sands of undetermined age.

Following is the log of a well near Clarksville, in the northern part of Calhoun County:

*Fla. Geol. Surv., 5th Ann. Rept., p. 240, 1913.

Samples from Calhoun Gas and Oil Company. About half a mile northwest Clarksville. Elevation of well estimated at 143 feet. Well begun October 15, 1919; completed to 1,320 feet October, 1920. Samples collected by W. A. Edwards, driller.

	<i>Depth from surface.</i>		
Iron-stained sand, some clay.....			10
Sand, some clay			20
Drab-colored, micaceous sands.....			30
Sand			40
Highly micaceous, clayey blue sand.....	50-	60-	70
Sand, shells (pecten), coral, etc.....	80-	90-	100
Sand, shell fragments			110
Sand, many shells			120
Micaceous sand with shell fragments.....			140
Sand and shells	130-		160
Sand, sandy clay and shells.....			180
Light-colored limestone	200-		220
Light-colored limestone, some small shells.....	240-		260
Light-colored, soft limestone or marl, with some clay.....			280
Light-colored, clayey marl or limestone.....			300
Same, together with sandy rock with greenish cast.....			310
Sandy limestone with greenish cast and some light marl.....	368-	380-	400- 420
Same, together with light-colored, porous limestone.....			440
Light-colored, porous limestone, many foraminifera.....			450- 555
White limestone, more large, flat foraminifera and other fossils			560
Soft, porous, white limestone, with fossils.....	565-		570
Similar rock, with many foraminifera.....	575-		610
Soft, white limestone	620-		660
Medium hard, white limestone.....			670
Soft, white limestone	680-		730
Soft, white limestone or marl.....	740-		750
Interval 750 to 900. No samples. Driller W. A. Edwards says all white, soft rock, returns milky.			
Drab-colored, very calcareous clay or marl, little or no sand. Disintegrates in water			915
Soft, gray white marl or limestone.....	945-		960
Soft, white, granular limestone.....			975
Soft, white, granular limestone, some sand.....	995-		1000
Chiefly coarse sand, some limestone and some glauconite.....			1005
Coarse, calcareous, glauconitic sand.....	1010-		1015
Sandy limestone or calcareous sandstone, with glauconite.....	1020-		1030
Limestone, slightly yellow, many foraminifera			1040
Soft, white limestone, with foraminifera	1050-		1060
Limestone, with foraminifera and sand.....			1070
Fine, calcareous sand, gray or light.....			1080
Light, calcareous sand or sandy limestone, more porous.....	1100-		1110
Very calcareous, fine sand, many foraminifera.....			1120
Very calcareous, fine sand.....			1130
Very sandy, light-colored limestone or marl.....			1140
Light-colored limestone, some sand, some foraminifera.....			1150
Very calcareous, light-colored sand, some mica.....	1160-		1170
Very calcareous, light sand, some foraminifera.....	1180-		1200
Limestone and sand, many foraminifera, some glauconite.....	1210-		1220-1230
Very calcareous sand or sandy limestone.....			1240
Coarse, calcareous sand, with glauconite.....			1250
Green-colored, calcareous and glauconitic sand.....			1260

	<i>Depth from surface.</i>
Calcareous, fine, green sand, some clay.....	1270
Medium fine, glauconitic and calcareous sand.....	1280
Coarse, calcareous sand and glauconite.....	1290
Gray, medium fine, calcareous sand, with some glauconite.....	1300-1320

CHARLOTTE COUNTY

Charlotte County on the Gulf coast of southern Florida includes pre-vaillingly level land of but moderate elevation. In the western part of the county are found exposures of Pliocene shell marls, and these shell beds probably underlie much of the county. No wells of great depth are recorded, although artesian water is obtained from about 200 to about 500 feet.

CITRUS COUNTY

Citrus County is in the Brooksville geological area and lies between the Withlacoochee River and the Gulf of Mexico. The surface formations in this county are chiefly Eocene, with probably some Pleistocene in the river valleys and near the coast. Remnants are present of the Alum Bluff Miocene, as well as local deposits of a phosphate-bearing formation derived from the Alum Bluff formation. One well has been drilled near Crystal River, said to have reached to a depth of 1,900 feet. This well, of which no log is available, obtained flowing salt water.

CLAY COUNTY

Clay County is located in northeast Florida on the west side of the St. Johns River. From the St. Johns River the elevation rises rapidly and the western margin of the county extends to the highlands crossed by Trail Ridge. On Black Creek, in this county, are seen exposures of Miocene phosphatic marls. From available well records it appears that the Eocene limestones are reached in the eastern part of this county at a depth of about 400 feet. Flowing artesian water from Eocene (or older?) formations is obtained at Green Cove Springs, Doctor's Inlet and elsewhere in this county.

COLUMBIA COUNTY

In the southern part of Columbia County the Ocala formation (Eocene) is found at the surface. In the central and northern parts of the county this formation disappears below the surface and the Alum Bluff

formation comes into the section. A number of water wells have been drilled in this county, although none of them exceed 400 or 500 feet in depth. No logs of these wells are available. However, it is probable that after passing through the sands and clays of the Alum Bluff formation, Eocene and probably older limestones are encountered. The dip of the Eocene limestones in Columbia County is probably to the north or northeast, as the county lies on the east of the Live Oak dome and on the north flank of the central Florida uplift.

DADE COUNTY

Dade County is on the Atlantic coast of southern Florida. The surface formations in this county are Pleistocene and include oolitic limestones and shell marls. The thickness of the Pleistocene in wells in this county has not been recorded. Deep wells have been drilled at Miami Beach, a log of which follows. It is possible that the Eocene formations lie as much as 1,000 feet or more below the surface in the eastern part of this county:

Composite log of two wells drilled at Miami Beach, Dade County. Log received from, and used by permission of, United States Geological Survey.

	<i>Thickness.</i>	<i>Depth.</i>
Sand and shell	5	0- 5
Black muck	2	5- 7
First rock	2	7- 9
Quicksand and water	12	9- 21
Lithia lime	12	21- 33
Quicksand	30	33- 63
Coquina rock	20	63- 83
Soft sand	14	83- 97
Soft sand, rock	30	97- 127
Lime shell	2	127- 129
Soft rock	23	129- 152
Lime shell	2	152- 154
Gray coquina rock	18	154- 172
Hard lime and shell	5	172- 177
Soft, yellow coquina	30	177- 207
Lime shell	2	207- 209
Soft coquina	21	209- 230
Blue mud	2	230- 232
Coquina rock	30	232- 262
Quicksand	3	262- 265
Soft sand rock	300	265- 565
Soft sand, with streaks of blue marl.....	200	565- 765
Greenish clay	5	765- 770
Soft sand rock	20	770- 790
Blue clay	5	790- 795

	<i>Thickness.</i>	<i>Depth.</i>
Soft sand rock	35	795- 830
Blue clay	4	830- 834
Soft sand rock	30	834- 864
Blue clay	5	864- 869
Lime shells	1	869- 870
Soft lime, first water.....	10	870- 880
Coquina rock	15	880- 895
Hard lime	5	895- 900
Sand, salt water	5	900- 905
Hard shell	2	905- 907
Sand rock, fresh water.....	8	907- 915
Lime shell	2	915- 917
Sand rock	10	917- 927
Lime	8	927- 935
White sand	4	935- 939
Lime	5	939- 944
Soft sand	5	944- 949
Shell	1	949- 950
Yellow sand	100	950-1050
Lime shell	2	1050-1052
Yellow sand	10	1052-1062
Lime shell	4	1062-1066

DE SOTO COUNTY

De Soto County lies north of Charlotte County, near the Gulf coast. In the western and northwestern parts of the county is found Lower Miocene (Alum Bluff), covered for the most part by a veneer of Pliocene (Bone Valley formation). No records of deep wells in this county are available, although water wells for public supplies have been drilled to a depth of 620 feet.

DIXIE COUNTY

Dixie County lies adjacent to the Gulf coast, west of the Suwannee River. On the Suwannee River, at the east side of this county are found exposures of the Ocala (Eocene) limestone. The Chattahoochee limestone is probably present as a thin formation over parts of the county. No deep wells are recorded.

DUVAL COUNTY

Duval County borders the Atlantic coast in northeastern Florida. The southwestern part of the county extends on to the uplands approaching Trail Ridge. The surface formations near the coast are Pleistocene, although at Jacksonville the Miocene comes to the surface. Wells drilled at Jacksonville indicate that Eocene limestones are reached at that place

at a depth of approximately 500 feet. Record has already been given (see Jacksonville Area) of a well at Jacksonville drilled to 980 feet. In this well the last 160 feet or more, according to Cushman, is Cretaceous.

ESCAMBIA COUNTY

Escambia County is the westernmost county of Florida. It has been shown that in Walton and Okaloosa Counties in Florida, and in southern Alabama, there is a pronounced southwest dip in the formations, and that the limestones which are found at the surface in the northern part of Walton County are buried to an undetermined depth at Pensacola. The surface formations in the southern part of this county are later than the Miocene, but otherwise undetermined as to age. The log of a deep well at Pensacola has already been given (see Pensacola Area).

FLAGLER COUNTY

Flagler County, on the Atlantic coast of Florida, includes mostly level lands, with few surface exposures. At the eastern margin of this county are found shell marls of Pleistocene age. Wells in this county pass through deposits below the surface, probably of Miocene age. At Orange Mills, in Putnam County, the Eocene lies at a depth of only 110 feet from the surface. It is probable, therefore, that in Flagler County these formations lie at no great depth.

FRANKLIN COUNTY

Franklin County borders the Gulf of Mexico and lies between the Apalachicola and Ocklocknee Rivers. Its location is thus at the south side of the Quincy Area, elsewhere described, and southwest of the Tallahassee Area. From its location it is probable that the formations dip to the south or southwest. At the extreme northeast boundary of the county the Lower Miocene formations are probably at or very near the surface. To the west and southwest from this place these formations lie below the surface. Owing to the prevailing level surface, but few exposures are seen. On New River, at Knox Still Landing, about fifteen miles by water from Carrabelle, will be found an exposure of limestone or marl, from which a small collection of fossils was obtained by the writer in 1915. These fossils have been identified by T. W. Vaughan, of the U. S. Geological Survey, as representing either Miocene or Pliocene.¹

¹Letter of December 16, 1915.

Partial Log of the Well of the Carrabelle Oil and Development Company²
(From samples in possession of the U. S. Geological Survey.)

	<i>Depth in feet.</i>
Sand, light brown	18- 20
Sand, dark brown	49- 50
Sand, dark brown	58- 60
Sand, light yellow, coarse, and fine gravel, with some shell fragments.....	65- 67
Sand, dark brown	68- 69
Same, with shell fragments.....	69- 70
Limestone, hard, gray	70- 72
Same, with casts of shells.....	78- 84
Clay, greenish, containing limestones.....	100-110
Limestone, dark gray, granular.....	120-125
Limestone, dark gray	139-141
Limestone, light gray	140-144
Limestone, porous, gray	146-149
Limestone, light gray	159-160
Clay, dark gray, shell fragments.....	194-195
Same	209-210
Limestone, light gray, granular.....	220-222
Limestone, light gray, porous.....	230-240

GADSDEN COUNTY

Gadsden County includes some of the highest land in Florida. With respect to structural features, however, this area is probably low, occupying a syncline. An explanation of the topographic development of this part of the State has been given in earlier reports of the Florida Survey.*

At the western boundary of this county on the Apalachicola River the Chattahoochee formation (Oligocene) lies at the surface. Occasional exposures of this formation are found also on the Ocklocknee River in the northeastern part of the county. The central part of the county is occupied by the Lower Miocene Alum Bluff formation, and in the southeastern part of the county the Upper Miocene shell marls come into the section.

The log of a well at Quincy has already been given. (See Quincy Area.)

A deep well was drilled near Greensboro as a test for oil, but unfortunately no samples or other adequate record of the boring is available. Drilling was begun in 1917 and continued to a depth of about 1,750 feet. The well was cased with six-inch casing to a depth of about 1,300 feet,

²Water Supply Paper 319, U. S. G. S., p. 305, 1913.

*Fla. Geol. Surv., 2nd Ann. Rept., p. 261, 1909.

below this no casing used. Salt water is reported at about 1,300 feet.* From an examination of the debris on the dump it is believed that this well entered or passed through the Eocene.

GLADES COUNTY

Glades County lies west of Lake Okeechobee. The land is prevailingly level and there are few natural exposures. Pleistocene and Pliocene shell marls underlie the southern part of the county, having been exposed by canal cutting.

The deepest well in Glades County of which record has been obtained is the one owned by the Florida Ice and Power Company, of Moore Haven. This well was begun in May, 1918, and completed July, 1919. C. M. Boland, of Bartow, contractor; R. A. Black, driller in charge, when well was completed. Total depth, 806 feet.

The following partial log of this well was obtained through correspondence with Mr. Black, dated July 15, 1919:

Log From 642 to 794 Feet

	<i>Depth in feet.</i>
Sandy lime	642-707
Dark marl	707-748
Shell	748-753
Blue marl	753-765
Shell	765-772
Brown marl	772-785
Dark shell	785-789
Black sand	789-794
Limestone, hard drilling	794-798

Flowing salt water at 792 feet. Six-inch casing set in at 792 feet and driven to 794 feet 10 inches, cutting off salt-water flow. At 798 feet flow of fresh water obtained, reported pressure of 18 pounds. Capacity, 800 gallons per minute.

HAMILTON COUNTY

Hamilton County is located in north Florida, its northern boundary being the Georgia-Florida state line. The Suwannee River forms its east and south boundaries and the Withlacoochee River its west boundary. Over the greater part of this county the Alum Bluff formation (Miocene) lies at or near the surface. In this respect the county af-

*Notes from letter August 1, 1921, from Mr. J. L. Shepard, on whose property the above well was drilled.

fords a contrast to the counties farther south, where the Eocene formations are exposed. Hamilton County apparently lies in a syncline lying north of the structurally high area of Suwannee County. Water wells of moderate depth have been drilled in the county, but none of these exceed 500 feet, and of the wells of this depth no adequate record has been obtained.

HARDEE COUNTY

The formations found at the surface in Hardee County include the Alum Bluff and Bone Valley formations, with probably some later deposits. The Alum Bluff formation is found exposed chiefly on the streams, being elsewhere very generally covered by the Bone Valley formation, which in places is phosphate bearing. Artesian water is obtained in Hardee County from 90 to about 800 feet.

HERNANDO COUNTY

Hernando County is on the Gulf coast in west central Florida and extends east to the Withlacoochee River. It includes in the central part of the county some relatively high rolling lands. The Tampa and Alum Bluff formations are exposed in the central or highland parts of this county, while toward the eastern part of the county, near the Withlacoochee River, the Eocene comes to the surface.

During the latter part of 1920 a well was drilled for the Buttgenbach Phosphate Company, near Croom, by Mr. J. O. Edson. Through the courtesy of Dr. H. G. Bystra, the following notes and general log of this well were obtained:

Log of well drilled for Buttgenbach Phosphate Company, near Croom. Drilled 1920. Water stands about 42 feet from the surface. Cased to a depth of only 79 feet with 12-inch casing. Yields 1,200+ gallons of water per minute.

	<i>Depth in feet.</i>
Surface sand and clay.....	0- 20
Soft phosphate	20- 50
Gravel and boulder phosphate.....	50- 55
Hard crystalline limestone	55- 65
Limestone, quite uniform	65-878

During the process of drilling, cavities in the limestone were encountered at 440 feet and at 868 feet.

HIGHLANDS COUNTY

Highlands County lies west of the Kissimmee River and extends west to and includes the southernmost part of the lakes of the lake region of Florida. In the lake region are found sands and sandy clays, with more or less kaolin, the age of which has not been satisfactorily determined. Aside from these deposits, exposures in the county are rare and the geology imperfectly determined.

In 1919 a well was drilled by E. A. Durst at Sebring, in this county, to a depth of 1,200 feet. This is an 8-inch well, cased to 404 feet. The water is reported to stand 60 feet from the surface.

HILLSBOROUGH COUNTY

Hillsborough County is on the Gulf coast of southern Florida. The surface formations in the northwestern part of this county, at Tampa and on the Hillsboro River, are the Tampa limestone of Oligocene age. In the southern part of the county the Alum Bluff formation (Miocene) is at or very near the surface. Some Pleistocene is to be expected near the coast, and in the eastern part of the county a thin veneer of Pliocene (Bone Valley formation) overlies the Alum Bluff (Miocene).

Numerous wells have been drilled for water at Tampa and elsewhere in this county. Following is a log of a well drilled at Ft. De Soto, made up from samples of cuttings; record from U. S. Geological Survey, Water Supply Paper No. 319, p. 321, 1913:

Log of the Well at Ft. De Soto

From samples of drillings furnished by S. W. Bryan.

	<i>Depth from surface.</i>
Sand, fine, white; fragments of shells.....	0- 6
Sand, mixed fine, white and dark colored, with fragments of shells.....	6- 30
Sand, dark gray to greenish gray; partly consolidated.....	30- 55
Limestone, dense, gray, porous, containing some shells.....	55- 64
Limestone, dense, gray, and granular gray sandstone; numerous shells.....	64- 85
Limestone, light gray, porous.....	85- 96
Limestone, mixed light and dark gray.....	96-110
Shells and shell fragments.....	110-118
Limestone, dense, dark gray.....	118-130
Marl, fine grained; a few shell fragments.....	130-145
Limestone, dense, dove-colored.....	145-158
Limestone, fine, white.....	158-175
Limestone, light, dove-colored.....	175-190
Marl, thin, granular, containing sand.....	190-212
Sand, pale yellow.....	212-226

	<i>Depth from surface.</i>
Limestone, granular, light gray.....	226-240
Sand, fine, gray, gray granular limestone, and wine-colored silex.....	240-260
Marl, fine, gray, sandy, with wine-colored silex.....	260-280
Limestone, fine, gray, sandy.....	280-338
Sand, light gray.....	338-350
Limestone, porous, white.....	350-360
Limestone, coarse grained, gray.....	360-375
Limestone, yellowish gray, containing some chert.....	375-388
Limestone, gray, containing chert.....	388-420
Chert, dark gray.....	420-425
Limestone, light gray.....	425-431
Limestone, white.....	431-470
Limestone, pinkish gray.....	470-490
Limestone, very fine grained, dense, white.....	490-508
Limestone, coarse grained, brownish gray.....	508-525
Limestone, light gray.....	525-575
Limestone, medium grained, light gray.....	575-590

HOLMES COUNTY

Holmes County, in west Florida, adjoins the Alabama-Florida state line. On the Choctawhatchee River, near the Alabama boundary, is found an exposure of Ocala Eocene.* Downstream from this exposure to or nearly to the Louisville and Nashville Railroad crossing, are occasional exposures of Upper Eocene or Lower Oligocene limestones. In the southwestern part of the county the Alum Bluff Miocene, represented by shell marls, come into the section.

No deep wells have been drilled in this county. The underground conditions are probably not unlike the conditions encountered by the Chipley well in Washington County.

JACKSON COUNTY

Jackson County adjoins the Alabama-Florida state line west of the Apalachicola River. On the Chipola River, in this county, the Eocene and Oligocene limestones, Ocala and Marianna formations, are found at the surface for several miles south of Marianna.

In the southern part of the county on the Chipola River, and in the eastern part of the county on the Apalachicola River the Chattahoochee limestone (Oligocene) is at the surface. In the southwestern part of the county the Alum Bluff formation is found at or near the surface.

Jackson County is located on the structurally high area extending into Florida from Alabama and Georgia. The dip of the formations is probably southeast and south.

*Identified by C. Wythe Cooke, U. S. Geol. Surv., letter March 29, 1922.

A well drilled for the city of Marianna in 1921 reached a depth of 255 feet. This is the source of the public water supply and is a 10-inch well, with a head of 47 feet from the surface. No samples of the drillings were saved, but the following general log was obtained from the contracting engineers, the Albany Electric Company, Albany, Ga.:

Log of New City Well, Marianna

Surface soil and clays.....	1- 39
Flint rock	39- 41
Hard limestone	41-186
Cavity	186-190
Hard limestone	190-212
Flint rock	212-226
Cavity	226-229
Porous limestone	229-250
Flint rock	250-253
Cavity	253-255

JEFFERSON COUNTY

Jefferson County is in north Florida and extends from the Florida-Georgia state line south to the Gulf of Mexico. In the southern part of the county the Chattahoochee limestone is at the surface. In the northern part of the county this formation lies near the surface and is occasionally exposed in stream valleys, sinks and lake beds. Overlying the Chattahoochee formation in the northern part of the county is the Alum Bluff formation, together with red, sandy clays of undetermined age.

Water wells have been drilled to a depth of 800 feet, but of these wells no record is available.

LAFAYETTE COUNTY

Lafayette County lies west of the Suwannee River and north of Dixie County. According to Matson, the Alum Bluff formation is present in this county.¹ The Chattahoochee limestone probably underlies the Alum Bluff. No deep wells are recorded in this county.

LAKE COUNTY

Lake County is in the lake region of central peninsular Florida. The surface materials over a large part of this county include red, sandy clays of undetermined age. At the eastern side of the county, on the St.

¹U. S. Geol. Surv., Water Supply Paper No. 319, p. 335, 1913.

Johns River, is found Pliocene shell marls, Nashua formation. Underneath these surface materials the Miocene is probably represented by shell marls, clays and sands. The Eocene is probably present, although thin, and at less than 200 feet, probably 160 feet at Eustis, the Cretaceous is entered. The water wells of this county vary from less than 100 to over 500 feet in depth.

LEE COUNTY

Lee County, in southern Florida, borders the Gulf of Mexico and extends east to the Everglades. In the northern part of the county, on the Caloosahatchee River, the Pliocene shell marls (Caloosahatchee marls) are exposed. Farther to the south and east, including most of the county, the surface formations are Pleistocene sands and fresh-water limestones. This county extends west and includes the keys and islands at the entrance to Charlotte Harbor. On these islands the Alum Bluff formation probably lies rather near the surface, being concealed by surface materials. The log of a well drilled at Ft. Myers has already been given. (See Ft. Myers Area.)

The dip of the formations in this county is in general to the southeast. Some mild folding later than the Pliocene is seen in the marl beds on the Caloosahatchee River.

LEON COUNTY

Leon County is located in north Florida, east of the Ocklocknee River. The oldest formation exposed in this county is the Chattahoochee limestone. This formation lies at the surface in the southern part of the county and is occasionally exposed in sinks, stream beds, and lake basins to the north county line. Overlying the Chattahoochee limestone in the northern part of the county are the Alum Bluff sands and clays, and this formation in turn is to some extent concealed by surface materials consisting of red sands and sandy clays of undetermined age. In the southwestern part of the county, at Jackson Bluff and elsewhere, the Upper Miocene shell marls (Choctawhatchee formation) come into the section.

Water wells have been drilled at Tallahassee to a depth of about 700 feet. Following is a log of the deepest of these wells. Some samples of cuttings from this well are preserved in the Walker Library at Tallahassee:

Log of the city well at Tallahassee, Florida. Drilled by Arthur Durst, August 15 to December 18, 1891. Log and notes as made out by Major Robert Gamble.

	<i>Thickness.</i>	<i>Depth.</i>
Surface soil	41	0 - 41
Limestone	250	41 - 291
Hard, brown stone	23	291 - 314
Soft, white limestone	34	314 - 348
Hard, yellow stone	7	348 - 355
Hard, white stone	3	355 - 358
Hard, red quartz	2 in.	
Hard, brown stone	13	358 - 371
Soft, yellow mud	2	371 - 373
Hard, brown stone	4	373 - 377
Hard, gray stone	2	377 - 379
Rose-colored marble	2	379 - 381
Hard, brown stone	4	381 - 385
Fine Sand	$\frac{1}{2}$	385 - 385 $\frac{1}{2}$
Hard, brown stone	8	385 $\frac{1}{2}$ - 393 $\frac{1}{2}$
Soft stone, alternating in brown and white strata	112	393 $\frac{1}{2}$ - 505 $\frac{1}{2}$
Soft, white stone	207	505 $\frac{1}{2}$ - 712 $\frac{1}{2}$

A well is being drilled about three miles east of Woodville, in the southeast portion of the county, as a test for oil. This well is being bored by the Central Florida Oil and Gas Company, with offices in Tallahassee, and was begun in March, 1921.

LEVY COUNTY

Levy County is on the Gulf coast, in the northern part of peninsular Florida.

Eocene limestones form the substratum in this county and come to the surface at many places. Overlying the Eocene in places is a thin covering of the Alum Bluff (Miocene), consisting of sands and clays. The Alachua clays, sands and phosphate beds (Pliocene) are present in local areas in the northeastern parts of the county.

At Cedar Keys, on the Gulf coast, some wells have been drilled to about 800 feet in depth, but of these wells no logs are available.

LIBERTY COUNTY

Liberty County is located in west Florida, on the east side of the Apalachicola River. On this river may be seen in order, from north to south, exposures of the Chattahoochee formation (Oligocene); the Alum Bluff formation (Lower Miocene), and the Choctawhatchee formation (Upper Miocene). On the Ocklocknee River, which forms the

east boundary of the county, the Alum Bluff and Choctawhatchee formations are at the surface. Localities where these formations may be seen are as follows: Chattahoochee formation at Rock Bluff, in the northwestern part of the county, and on various streams in this part of the county; Alum Bluff formation at Alum Bluff on the Apalachicola River, and at numerous localities on the Ocklocknee River through the county; the Choctawhatchee formation may be seen at Alum Bluff on the Apalachicola River, and at Jackson Bluff on the Ocklocknee River, and also at many localities on small streams in the central part of the county. The dip of the formations in this county is in general southward. In the northwestern part of the county the direction of maximum dip may be somewhat east of south, while in the southeastern part of the county the maximum dip is probably west of south.

MADISON COUNTY

Madison County borders the Georgia state line and lies west of the Withlacoochee and Suwannee Rivers. In the southern part of this county the Chattahoochee limestone is at or near the surface. In the northern part of the county this formation, for the most part, is concealed by the Alum Bluff formation, but is occasionally exposed in sinks, stream valleys and lake basins throughout the county. The surface materials include red, sandy clays and sands of undetermined age. The Ocala limestone possibly comes to the surface on the Suwannee River in the southeastern part of the county. No record of deep wells has been obtained in this county.

MANATEE COUNTY

In Manatee County the Alum Bluff formation (Miocene) lies either at the surface or at no great depth below the surface. In the northwestern part of the county this formation may be seen exposed in the banks of the Manatee River. In the interior of the county it is covered by later deposits, probably, chiefly by Pliocene deposits which are equivalent in age to the Bone Valley formation. Thin Pleistocene shell marls are found at some localities near the Gulf coast and may be seen in pits opened up for road material at Bradentown. The Tampa formation (Oligocene) and the Ocala formation (Eocene) probably are present, underlying the surface formations. No wells of great depth have been

drilled in this county, although numerous wells have been drilled for water, ranging in depth from about 110 to 760 feet.

MARION COUNTY

In the western half of Marion County the Ocala limestone (Eocene) lies at or very near the surface. Overlying the Ocala limestone in this part of the county are found remnants and, in places, considerable areas of the Alum Bluff clays and sands (Lower Miocene). A part of west Marion County contains also local deposits of the Alachua clay, including sand and phosphate beds. These later deposits, the Alum Bluff and Alachua formations, will be found as a rule to vary from 20 to 100 or 150 feet in thickness.

According to studies made by Cushman, it appears that the Ocala limestone in this county is possibly not more than 40 or 60 feet thick. Underlying the Ocala, other thin limestones are found, possibly of Claiborne age, and at no great depth Cretaceous sediments, regarded by Cushman as Lower Cretaceous, are entered.

Several deep wells have been drilled in this county and the sediments are shown to be limestones to a depth of 1,200 feet or more.

The eastern part of Marion County differs from the western part in that the Eocene limestones dip out of sight and are so deeply buried as not to influence the topography. Some of the springs of the county flow salty water. The largest of these is known as Salt Spring, near Norwalk. The geology of the eastern part of this county has been but little studied. It is probable that the Miocene and possibly also Pliocene formations are at the surface.

Following is the log of a well drilled at Anthony. The log is made up from samples preserved by the owners of the well:

Log of well of Compagnie Generale des Phosphates de la Floride, Anthony, Marion County, Florida. Well drilled 1908. Water-well yield, 1,600 or 1,700 gallons per minute.

	<i>Depth of sample.</i>
Soft, white limestone, granular, apparently Eocene. Contains many foraminifera and fragments of shells.....	50
Possibly somewhat harder, but not materially different from above.....	75-100
Limestone of above predominates. Fragments of blue-gray like the following are included	110
A hard, blue-gray limestone predominates in the sample from this depth. Some fragments of the white limestone are included. One unbroken piece indicates that these blue fragments are imbedded in a matrix of light-colored material	130

	<i>Depth of sample.</i>
Possibly somewhat more granular, but otherwise not differing from the white limestone above	160-200
A gray or light blue-gray, compact limestone not unlike that found at the depth of 130 feet, although possibly harder.....	260
White granular limestone	300
Gray limestone, very compact. The sample contains, however, one piece which is very porous.....	350
Granular, white limestone	375
Porous, white limestone, appearing nearly cream-yellow in the powdered form	430
Material similar in character to the last, but of a darker color, nearly cream-yellow	440
Darker in color and may be described as a brown limestone, which is apparently rather porous	445
Mixture of brown and light-colored limestones, with occasional grains of silica, the brown predominating.....	460
Dark brown, porous limestone.....	480
Dark brown limestone	500

This well starts in the Ocala formation (Eocene), and is reported by Cushman to enter the Lower Cretaceous at 110 feet.

MONROE COUNTY

Monroe County extends to extreme south Florida and includes the Florida keys south of Key Largo. The surface formations in this county are Pleistocene or Recent in age, and include coral and oolitic and fresh-water limestones and sands. Underneath the Pleistocene are Tertiary sediments, and beneath the Tertiary is the Cretaceous.

The log of a well at Marathon, in this county, has already been given (page 95). At this place the Lower Cretaceous fossils are recorded by Cushman at 1,248 feet. The log of a well at Key West, to a depth of 2,000 feet, is given in the Fifth Annual Report of the Florida Geological Survey, page 288. This well is reported to have reached a total depth of 2,398½ feet.*

NASSAU COUNTY

Nassau County is on the Atlantic coast, in extreme northeast Florida. On the St. Mary's River, which forms the west and north boundaries of this county, deposits of probably Pliocene and Pleistocene age are at the surface. Elsewhere in the county such limited exposures as are seen consist chiefly of sands and sandy clays of undetermined age. The Alum

*U. S. Geol. Surv., Water Supply Paper 319, p. 372, 1913.

Bluff formation (Miocene) is evidently present under the surface formations, as indicated by well logs in which the phosphatic clays and marls are recorded. The Eocene limestones are probably reached at from 400 to 500 feet from the surface. The following log of a well at Callahan indicates the drilling conditions to a depth of 489 feet.*

	<i>Depth in feet.</i>
Sand	0- 2
Red clay	2- 10
Blue clay and sand.....	10- 45
Shell deposit, including a thin layer of hard rock at 52 feet. Water above and below this rock comes to within 10 feet of surface.....	45- 60
Blue marl, with occasional beds of shells 3 or 4 feet thick, and containing black to dark gray, water-worn pebbles.....	60-200
Medium coarse sand, with numerous very small, black grains or pebbles. A flow was obtained at this depth.....	200-212
Limestone (sample)	212-255
Blue marl and fine sands, with inclusions of several thin strata of shell. (Sample)	255-355
Very hard rock	355-364
Indurated gray sand and blue marl.....	364-418
Rock, hard and soft strata, with increase of flow upon penetrating each hard stratum. No increase reported below 460 feet. Driller reports the rock to be closer grained from 460 to 489.7 feet, and not containing much water	418-489.7

OKALOOSA COUNTY

Okaloosa County, in western Florida, extends from the Alabama line to the Gulf of Mexico. In the north northeastern part of this county are found numerous exposures of shell marls of the Alum Bluff formation (Miocene). These marls may be seen on Yellow River, near Oak Grove, this being the type locality of the Oak Grove member of the Alum Bluff formation. On Shoal River, near the east county line, are shell marls referred to the Shoal River member of the Alum Bluff formation.

The dip of the formations in this county is south or southwest. Approaching the Gulf coast, formations later than the Alum Bluff probably come into the section. However, from lack of exposures the age and character of these later formations are unknown.

No deep wells have been drilled in this county.

OKEECHOBEE COUNTY

Okeechobee County lies north of Lake Okeechobee. The land is level, affording few exposures. From well records it is known that Pleisto-

*Fla. Geol. Surv., 5th Ann. Rept., p. 166, 1913.

cene shell marls underlie the Kissimmee Valley. Record of a deep well at Okeechobee has already been given under the discussion of the Kissimmee Area.

ORANGE COUNTY

Orange County lies chiefly within the lake region of Florida, and much of the surface material, including sands and sandy clays, are of undetermined age. However, near the west line of the county, at Rock Springs, deposits of Miocene age are exposed.¹ In the eastern and southern parts of the county the formation at the surface may be as late as the Pliocene or Pleistocene. Fossiliferous exposures of this age, however, are not known in the county.

Wells drilled at Orlando, in the central part of the county, indicate that limestones probably, although not certainly, Eocene in age, are reached at between 150 and 250 feet from the surface.

OSCEOLA COUNTY

The surface in Osceola County is prevailingly level or but slightly rolling. Such limited exposures as are to be seen consist largely of residual or more or less leached material, lacking fossils, and of undetermined age. From well records, however, it is known that a considerable thickness of Pleistocene is found in the Kissimmee Valley, and it is probable, from the distribution of formations elsewhere, that the eastern part of the county includes either Pleistocene or Pliocene formations.

In 1914 the Kissimmee Oil Company began drilling a test well for oil on the McCool farm on Lake Tohopekaliga, Section 25, T. 26 S., R. 29 E. This well was drilled 2,000 feet or deeper. The following is a log of this well, based on samples of the drillings:

Record of well of the Kissimmee Oil Company, located about 8 miles south of Kissimmee on the McCool farm, bordering Lake Tohopekaliga, Section 25, Township 26 S., Range 29 E. Samples from the surface to the depth of 1,872 feet submitted March 21, 1921, to the Geological Survey by Bartlett G. Long, Consulting Geologist. Six samples, representing the drillings from 1,865 feet to 2,000 feet, were submitted June 6, 1917, by Mr. G. F. Kribbs, Kissimmee, Fla. Drilling began in 1914; well abandoned in August, 1917.

	<i>Depth from surface.</i> (Ft.)
Fine, dark gray, surficial sands.....	0- 5
Very fine, brownish sand, with small amount of clayey material.....	60

¹Smith, E. A., Amer. Journ. Sci., 3rd Ser., Vol. 21, pp. 302-303, 1881.

Depth from surface.
(*Ft.*)

Greenish, sandy marl, with fragments of shells and some minute mica flakes. Echinoderm spine noted.....	150
Granular, light-colored limestone. Microscopic fossils.....	215
Very finely powdered, cream-colored limestone. Microscopic fossils.....	260
Hard, close-grained, light-colored limestone. Fossils.....	455
Finely powdered, brownish limestone.....	485
Finely powdered, brownish limestone. Microscopic fossils.....	515
Very hard, close-grained, brownish limestone. A few microscopic fossils noted.....	600
Hard, cream-colored limestone. No fossils observed.....	680
Hard, brownish limestone.....	715
Hard, finely-powdered, brownish limestone.....	870
Partly crystallized, brownish limestone.....	975
Light brownish limestone.....	1160
Hard, partly crystallized, brownish limestone.....	1210
Finely-powdered, crystallized, brown limestone.....	1300
Very finely-powdered, brownish limestone, with inclusions of flint fragments.....	1370-1380
Very finely-powdered, white limestone.....	1400-1410
Granular, light-colored limestone. Fossil noted.....	1410-1420
Granular, light-colored limestone.....	1420-1430
Hard, brownish limestone.....	1490
Finely-powdered, brownish limestone.....	1535
Very finely-powdered, brownish limestone.....	1545-1555
Very hard, brownish limestone.....	1564-1574
Finely-powdered, chalky, white limestone.....	1600-1635
Light-colored limestone, with bluish fragments.....	1645
Light-colored limestone, with bluish fragments.....	1700-1710
Light-colored, fossiliferous limestone.....	1760-1763
Very finely-powdered, brownish limestone.....	1763-1777
Light-colored limestone.....	1777-1781
Light-brownish limestone.....	1781-1785
Light-colored, finely-powdered, partly crystallized limestone.....	1789-1790
Light-brown, finely-powdered limestone. Fossils noted.....	1793-1806
Light-brown, finely-powdered limestone. Fossils noted.....	1806-1810
Light-colored, finely-broken, partly crystallized limestone.....	1810-1817
Light-colored, finely-broken limestone. Fossils noted.....	1817-1828
Light brown, powdered, partly crystallized limestone. Fossils noted.....	1830-1835
Light brown, finely powdered, partly crystallized limestone. Fossils noted.....	1835-1845
Hard, brownish, partly crystallized, powdered limestone. Fossils noted.....	1845-1854
Brown, crystallized limestone, finely broken.....	1854-1865
Light brown, very finely-powdered limestone. Fossils noted.....	1865-1872
Light brownish limestone. Some of the limestone discolored by iron or rust spots. No fossils observed.....	1925-1945
Light-colored limestone, powdered fine by the drill. Salt-water horizon. No fossils observed. The bailer brought up small amount of rock. Drillings disappeared in the water.....	1945-1990
Light-colored limestone. No fossils observed.....	1993
Gray-colored, hard, partly crystallized limestone. Breaks in coarse fragments. No fossils observed.....	1995
Limestone, some of it light-colored and some brownish cast. Broken up medium fine by the drill. In addition to the limestone, this sample contains a limited amount siliceous sand.....	2000

PALM BEACH COUNTY

Palm Beach County is on the Atlantic coast, in south Florida. In the western part of the county, as indicated by the shell marls brought to the surface in the St. Lucie Drainage Canal, the Pliocene is very near the surface, being covered only by muck accumulation. In the eastern part of the county is found Pleistocene shell marls and a limited development of limestones.

A well drilled at Palm Beach indicated Eocene limestone at a depth of 915 or 1,000 feet. The formations above the Eocene probably include Pleistocene, Pliocene and Miocene. A log of this well has already been given. (See Miami Area.)

PASCO COUNTY

Pasco County is located on the Gulf coast and extends inland to the Withlacoochee River. In the northern part of this county the Ocala Eocene is found at the surface, while near the south side is found the Tampa formation. The Alum Bluff Miocene is found capping many of the hills of the interior of the county.

In 1917 a well located about four miles east of Dade City was drilled by Mr. J. M. Critchlow to a depth of 2,200 feet as a test for oil. Of this well no log is available, but it is reported by Mr. Critchlow that no shows of oil were encountered.

PINELLAS COUNTY

Pinellas County occupies the Pinellas peninsula and lies between Hillsborough Bay and the Gulf of Mexico. The Caloosahatchee (Pliocene) has been collected from a drainage ditch about three miles east of Largo.* The Alum Bluff formation (Miocene) is exposed in this county near Indian Rock, on the Gulf coast. Although but little exposed, this formation probably underlies much of the county. The Tampa formation (Oligocene) has been determined from exposures near Tarpon Springs, in the northern portion of the county.† Some Pleistocene deposits are to be expected in this county near the coast.

A well was begun November 24, 1921, by Mr. R. V. Hill near Oldsmar, in the extreme eastern part of the county, as a test for oil.

The following is a log of a well at Clearwater:

*Collection made by Herman Gunter. Determinations by Miss Julia Gardner, U. S. Geol. Surv. Letter of C. Wythe Cooke, March 29, 1922.

†From letter of C. Wythe Cooke, March 29, 1922.

Log of City Well No. 6, Clearwater, Fla., Drilled by Porter May

	<i>Depth in feet.</i>
Sand	0- 16
Blue clay	16- 26
White rock	26- 73
Hard flint	73- 83
White coral	83- 94
Hard, gray rock	94- 98
Gravelly rock	98-103
Fuller's earth (?). Casing set at 112 feet.....	103-112
Hard, white rock	112-168
Flinty rock	168-176
Blue clay rock	176-179
Soft, white rock	179-183
Coarse, porous rock	183-188
Hard rock	188-215
Soft, gray rock	215-238
Hard rock	238-245
Gray, porous rock	245-287

Water rock 112 to 245. No increase in water after 245.

POLK COUNTY

Polk is one of the large counties of southern Florida. The central part of this county is in the uplands of the Lake Region, while the western part of the county includes the principal phosphate-producing section of the state. The phosphate beds of commercial value are found chiefly in the Bone Valley formation, which is of Pliocene age. The Bone Valley formation in turn rests upon the Alum Bluff formation, which is here also more or less phosphate bearing. The phosphate of the Bone Valley formation, in fact, represents more or less enriched concentrates from the Alum Bluff formation.¹ In some of the stream beds are Pleistocene and Recent deposits containing phosphate derived from the older formations.

The surface material in the lake region, consisting of sands and sandy clays, are non-fossiliferous and are of undetermined age. In the eastern part of the county, near the Kissimmee River, the Pleistocene beds of the Kissimmee Valley come into the section.

The log of a well near (Tiger Bay) Ft. Meade, in this county, has already been given. (See Tampa Area.)

¹Sellards, E. H., Fla. Geol. Surv., 7th Ann. Rept., p. 31, 1915.

PUTNAM COUNTY

Putnam County is on the St. Johns River, in northeast Florida. In the western part of this county the Alum Bluff formation (Miocene) is at or near the surface. Exposures of this formation may be seen at Grove Park, in Alachua County, a few miles west of the Putnam County line. The central part of this county lies in the lake region, and the surface formations are Miocene or later. Near the St. Johns River, in the eastern part of the county, the Nashua shell marl (Pliocene) comes into the section. The regional dip in this county is probably to the east or northeast, but is very moderate in amount. In the western part of the county the Eocene probably lies quite near to the surface. On the St. Johns River, at Palatka, these limestones, as indicated by well records, may be not more than 150 or 200 feet from the surface. At Orange Mills, in eastern Putnam County, the Eocene limestones were reached at 110 feet from the surface.

ST. JOHNS COUNTY

St. Johns County lies between the St. Johns River and the Atlantic Ocean, and ranges in elevation from sea level to about 50 or 60 feet. The surface in this county is very effectively concealed by sands and soil. Only on the coast and on inlets from the ocean have natural exposures been observed. The deposits seen consist of Pleistocene shell marls and coquina rock. From well records it is known that the combined thickness of the Pleistocene, Pliocene, if present, and Miocene is not more than 200 or 250 feet. At St. Augustine, the Eocene limestones are believed to lie not deeper than 224 feet from the surface, and at Hastings the Eocene appears from well records to be reached at from 175 to 200 feet. The record of a deep well drilled at St. Augustine and logs of several shallow wells are given in the Fifth Annual Report of the Florida Survey, pages 187-196.

ST. LUCIE COUNTY

Pleistocene shell marls and sands lie at or near the surface in much of St. Lucie County. These shell marls may occasionally be seen in natural exposures near the coast, but inland the land surface is for the most part so nearly level and the drainage courses so little developed that the

marls are seen only where cut into in the construction of drainage ditches. Excavations in which this marl is well exposed will be found west of the town of Vero and northwest of Ft. Pierce and at Fellsmere.

In the northern part of the county the Eocene limestone may lie within about 370 feet of the surface. This seems probable from the fact that at Fellsmere artesian water in quantity such as is usually obtained from the Eocene or older formations in Florida was secured at this depth. At Ft. Pierce, about 25 miles further south, the Eocene limestone has been identified from samples at a depth of 670 feet from the surface. If these records are correct, they indicate a south dip in the Eocene limestone, amounting to about 300 feet in 25 miles.

Following is the log of a well at Ft. Pierce, taken from the Fifth Annual Report of this Survey, page 247:

	<i>Depth in feet.</i>
Yellow sand	0- 55
Shell and sand	55- 75
Shell and gravel	75- 85
Shell, sand and clay.....	85-120
Blue clay and sand.....	120-135
Soft, blue clay and very fine sand.....	135-145
Blue clay and sand.....	145-165
Blue clay	165-190
Tough, dry, blue clay.....	190-200
Soft, sandy, blue clay.....	200-250
Hard, sandy, blue clay.....	250-300
Smooth, blue clay, no sand.....	300-400
Blue clay, very tough and sticky.....	400-460
Yellow clay, with black streaks in it.....	460-500
Yellow clay, with a few pebbles.....	500-520
Blue clay, tough and sticky.....	520-545
Very hard, yellow clay.....	545-555
Blue clay, very sticky.....	555-585
Yellow clay in hard and soft layers.....	585-600
Yellow clay, very dry.....	600-647
Shell and soft rock.....	647-656
Tough, white clay	656-662
Hard, white rock	662-676
Soft rock, small flow.....	676-685
Soft limestone rock, flow increasing very slowly with depth.....	685-807
Hard rock	807-814

SANTA ROSA COUNTY

Santa Rosa County, in west Florida, extends from the Alabama state line to the Gulf of Mexico. The surface deposits, as far as observed in this county, consist wholly of non-fossiliferous sands and more or less sandy clays. It is difficult to determine the age of such deposits.

The Alum Bluff formation dips under the county from the northeast and all surface formations, with the possible exception of those in the northeast portion, may safely be regarded as later than Lower Miocene. Near the coast the surface formations doubtless are Pleistocene. Pliocene and Upper Miocene sediments may be present in the central part of the county, although their presence has not been demonstrated.

No deep wells have been drilled in this county.

SARASOTA COUNTY

Sarasota County lies adjacent to the Gulf coast, in the southern part of Florida. The Alum Bluff formation is occasionally exposed on the coast and in stream beds in this county. Elsewhere it is overlaid by a thin veneer of later sediments, chiefly derived from the Alum Bluff.

No wells of unusual depth are recorded, although artesian water is obtained at depths ranging from 52 to 455 feet.

SEMINOLE COUNTY

With the exception of recent shell mounds on the St. Johns River, no deposits containing fossils by which the age of the formations may be determined have been found in Seminole County. It is known, however, from well drillings, that at Sanford the Eocene limestones are reached at the shallow depth of about 113 feet. The presence of the Eocene so near the surface at this place indicates a very mild dip to the east from the Eocene exposures of central Florida. No logs of the deep wells that have been drilled in this county are available. Shallow artesian wells are very numerous.

Following is a log of one of these shallow wells:*

	<i>Depth in feet.</i>
Surface soil	0- 5
Yellow sand	5- 40
Shell and sand, water, no flow.....	40- 60
Sand	60- 91
Shell and sand, with sharks' teeth.....	91- 95
Dark blue rock, with black phosphatic pebbles.....	95-100
Very dark rock	100-101
Light yellow sand	101-113
Limestone, Eocene	113

*Fla. Geol. Surv., 5th Ann. Rept., p. 219, 1913.

SUMTER COUNTY

Limestone, probably chiefly or entirely of Eocene age, lies at or near the surface in all of Sumter County. Overlying the limestone in places are remnants of the Alum Bluff formation (Miocene), although the areas in which the Alum Bluff persist are limited in this county.

Sumter County lies within the structurally high area of peninsular Florida and at least three deep wells have been drilled in this county as test wells for oil. Two of these were drilled by the Pearson Oil Company, in 1903. The deepest of these reached 2,002 feet and is said to have given shows of oil. A log of the third deep well, drilled in 1917-1918, has already been given. (See Ocala Area.) This well reached a depth of 3,090 feet and is the deepest well so far drilled in peninsular Florida.

SUWANNEE COUNTY

The oldest formation known to come to the surface in Suwannee County is the Ocala limestone, which may be seen at numerous exposures in the extreme southern part of the county and on the Suwannee River probably as far upstream as the Seaboard Air Line Railway crossing. The Chattahoochee limestone is found exposed in the vicinity of Live Oak and west to the Suwannee River. In the north-eastern part of the county these limestones are concealed by later deposits, probably chiefly of the Alum Bluff formation. From structural studies made by the United States Geological Survey in co-operation with the Florida Survey, it is concluded that a doming of the deeper formations is recognizable in the vicinity of Live Oak. (Thirteenth Annual Report, Florida Geological Survey, page 16.)

Wells have been drilled at Live Oak, in this county, to a depth of 1,078 feet, but no record is available. These wells start in the Chattahoochee limestone, but the thickness of this formation here is not known. The Ocala limestone may be expected at Live Oak, since it is exposed at localities on the Suwannee River. The thickness of the Ocala formation, if we may judge from well records in Marion County to the south-east, and in Wakulla County to the west, is likely to be less than 100 feet. The presence or absence of the Upper Cretaceous at Live Oak is undetermined. However, the water wells are said to indicate a succession of limestones quite similar to those found elsewhere in peninsular

Florida, in which it is believed that the Upper Cretaceous is wanting and that the drill passes from the Eocene limestones directly into Lower Cretaceous limestones.

TAYLOR COUNTY

The Chattahoochee limestone is found at or near the surface over a considerable part of Taylor County. Near the east line of the county the Eocene limestone may possibly be found at the surface. This, however, is merely a conjecture and has not been proven.

The Alum Bluff formation is possibly present locally in the county and Pleistocene deposits may be found near the coast.

Following is the log of a well at Perry, in this county. Unfortunately no samples were obtained and the age of the deeper limestones is unknown:

	<i>Depth in feet.</i>
Dry sand	0- 12
Sand with water	12- 14
Soft limestone	14- 16
Sand and water	16- 26
Decayed limestone, boulders, water.....	26- 180
Solid sand rock, very hard.....	180- 260
Honeycombed rock, containing water.....	260- 270
Hard, white and brown, flint rock.....	270- 430
Honeycombed rock, containing water.....	430- 440
Gray and white flint rock, very hard, with layers of white material like chalk. Water at 543 feet.....	440- 590
Cavity	590- 592
Very hard, solid rock.....	592- 596
Hard, flint rock	596- 600
Honeycombed rock, with water.....	600- 606
Hard, blue clay	606- 612
Hard rock. At depth of 1,000 feet small stream of water, with live-oak leaves. 4-inch pipe put in at this depth and driven in solid rock, cut- ting off all water above.....	612-1000
Hard, flint rock, with streaks of white material resembling chalk. Flow at this depth from 15 to 25 gallons per minute.....	1000-1207

UNION COUNTY

Union County lies south of Baker County, in northeastern Florida. Rocks of probably Lower Miocene age of the Alum Bluff formation are exposed in the southwestern part of the county, and probably underlie all of the county. Formations of later age than Lower Miocene may come into the eastern part of the county, although the surface there is very level, affording few exposures.

A well drilled for J. N. Townsend at Lake Butler reached a depth of about 600 feet. No log of this well, however, is available.

VOLUSIA COUNTY

In the western part of Volusia County, at DeLand and at DeLeon Springs, near the St. Johns River, shell marls of Pliocene age are exposed in pits opened for road material. On the Atlantic coast such exposures as are seen indicate Pleistocene at the surface.

From a well at DeLand, Miocene fossils were recognized by Vaughan at a depth of from 54 to 70 feet. At Daytona, on the Atlantic coast, the Eocene limestone apparently is reached at a depth of from 125 to 150 feet. A log of a well at New Smyrna has previously been given. (See Daytona Area.)

WAKULLA COUNTY

Wakulla County borders the Gulf of Mexico and lies east of the Ocklocknee River. The eastern half of this county shows chiefly exposures of the Chattahoochee formation (Oligocene). In the western part of the county the exposures, as seen on the Ocklocknee and Sopchoppy Rivers and their tributaries, are of the Alum Bluff formation (Miocene). The dip of the formations in this county as indicated by these exposures is west or southwest. Underlying the Chattahoochee limestone is the Ocala formation (Eocene), and beneath this is the Lower Cretaceous. A log of a deep well in this county has already been given. (See Tallahassee Area.)

A second well is being drilled by the Bonheur Development Company near the site of well No. 1. This well No. 2 was begun about November 1, 1919.

WALTON COUNTY

Walton County extends from the Alabama state line to the Gulf of Mexico. Near the north line of the county the Marianna and Ocala limestones are locally exposed at the surface. Through the central part of the county, near the Louisville and Nashville Railroad, is a belt of country containing exposures of the Alum Bluff shell marls (Lower Miocene. These marl beds may be seen near Eucheanna, Argyle and on Shoal River. In this county, near Red Bay, is found the type locality of the Choctawhatchee formation (Upper Miocene). Near the coast the formations are concealed, but are probably of later age than the Miocene.

During 1920 two wells, one about seven miles west of DeFuniak Springs and the other about twenty-five miles to the southeast, near

Bruce, were begun as tests for oil in this county. No set of the cuttings from either of these wells were procured and operations were suspended during the spring of 1921. From a log of the Bruce well it is seen that it attained a depth of at least 770 feet. The well drilled west of DeFuniak Springs, near Rat Head, is reported to be over 1,888 feet deep.

Following is the log of a well drilled as test for oil near Rat Head, Walton County, in S. 16, T. 3 N., R. 20 W. Well begun November, 1920. Log furnished by G. P. Billups, DeFuniak Springs, Fla.:

	<i>Depth in feet.</i>
Sand	0- 10
Clay	10- 20
Water sand	20- 28
Clay	28- 48
Sand	48- 108
Clay	108- 128
Sand	128- 188
Gray gumbo	188- 208
Sand and boulders	208- 263
Rock	263- 270
Shale and hard sand	270- 320
Sand and shell	320- 420
Shell and lime	420- 460
Sand	460- 560
Sand and shell	560- 760
Shell and sand	760- 790
Shell and sand	790- 875
Lime	875- 885
Brown sand	885- 889
Water sand	889- 907
Blue shale	907- 927
Water sand	927- 957
Shell and sand	957-1027
Blue shale	1027-1047
Gray lime and shell	1047-1065
Water sand	1065-1105
Shale	1105-1115
Coal (?)	1115-1122
Rock	1122-1124
Hard sand	1124-1184
Rock	1184-1186
Sand	1186-1276
Gumbo	1276-1286
Sand	1286-1306
Blue Shale	1306-1341
Black gumbo	1341-1401
Lime rock	1401-1405
Blue gumbo	1405-1444
Gray rock	1444-1447
Blue shale and gumbo	1447-1492
Gumbo and shale	1492-1630
Lime rock	1630-1636
Gumbo	1636-1645
Gumbo and shale	1645-1705
Brown shale	1705-1720

	<i>Depth in feet.</i>
Brown gumbo	1720-1750
Shale and gas	1750-1765
Gumbo	1765-1775
Brown shale	1775-1800
Gumbo	1800-1850
Pyrites	1850-1853
Brown shale	1853-1863
Gumbo	1863-1888

Following is the log of a well drilled as test for oil near Bruce, Walton County, in S. 17, T. 1 S., R. 17 W. Well begun November, 1920. Log furnished by G. P. Billups, DeFuniak Springs, Fla.:

	<i>Depth in feet.</i>
Water sand	0- 30
Blue clay	30- 34
Gray sand	34- 39
Blue shale	39- 45
Hard lime	45- 52
Blue clay	52- 94
Sand (show of oil and gas)	94- 97
Hard lime	97-108
Soft lime	108-137
Shell rock	137-160
Soft, white lime	160-197
Flint rock	197-200
Blue clay	200-221
Hard lime	221-228
Shell rock	228-251
White sand rock	251-265
Sand and shell rock	265-320
Blue shale	320-337
Blue clay	337-370
Gray sand rock	370-382
Soft lime	382-445
Blue flint	445-447
Blue clay	447-480
Hard, gray lime	480-483
Oil sand, dry	483-485
Yellow-brown sand rock	485-510
White lime rock	510-634
Blue clay	634-655
Lime rock	655-672
Oil sand (good showing)	672-674
Shell rock and lime mixed	674-765
White sand	765-770

WASHINGTON COUNTY

In the northeastern part of Washington County are found occasional exposures of the Ocala limestone. According to Cooke, some of the limestones found in this county are the Chattahoochee, and not the Marianna to which some of the exposures have previously been re-

ferred. In the southwestern part of the county on the Choctawhatchee River, the Alum Bluff formation lies at the surface. This county is located on the structurally high area of west Florida. The deepest well so far drilled in Florida is within this area, about four miles south of Chipley. Samples of the cuttings were saved at five-foot intervals, and the information which they afford will become available in time.

GENERAL CONSIDERATIONS

In estimating the probabilities of petroleum production in any locality, it is necessary to take into consideration the structural features and the character of the underlying sediments.

With regard to structural features in Florida, it may be said that there are pronounced structurally high areas of regional extent in the state, among which are the Marianna-Chipley Area, the Tallahassee Area, and the central peninsular Florida geanticline or dome, and in addition the somewhat isolated doming at Live Oak. It is probable that structural features favorable to the accumulation of oil exist within these areas, and may exist elsewhere.

When the character of the underlying rock is considered, it is found that in central peninsular Florida the rocks at one locality in Sumter County, to a depth of 3,090 feet, and to 2,555 feet on Key Vaca, Monroe County, have been shown to be chiefly limestones and marls, with relatively little or no bituminous matter. It is, however, possible that the sediments in some other localities in central peninsular Florida may be found to be more favorable than they appear in this one well, although such conditions have not yet been revealed by drilling. The age and characteristics of the formations underlying the Cretaceous in Florida has not been determined, as no wells in the State, so far as known, have reached or passed through the base of these formations.

In western Florida the sediments in Washington County were found to be somewhat bituminous and may reasonably be expected to produce oil under favorable sand and storage conditions.

With regard to locations for test wells, it would appear, in a state where but little prospecting has been undertaken, that if tests are to be made those areas in the state that are shown to present regional high structures should be selected for the first tests. The location of such regionally high areas has been indicated in this report.

INDEX

A

- Abe's Spring, exposures at, 98
- Accumulation of oil, 45
- Acknowledgments, 41, 42
- Alabama, extension of formations of in-
to Florida, 67, 72, 73, 103, 108
- geologic map, reference to, 67
- thickness of Claiborne in eastern, Ala-
bama, 72
- Alachua, record of well at, 96
- Alachua County, 60, 64, 70, 80, 95, 120
- Alachua formation, 64, 65, 95, 111, 113
- thickness of, 113
- Alaqua Creek, 65
- Albany Electric Co., 109
- Alphano Humus Co., 28
- Alum Bluff, exposures at, 63, 112
- Alum Bluff Formation, character of sedi-
ments of, 62
- description and distribution of, 62, 65,
67, 75, 80, 84, 95, 100, 102, 104, 113,
115, 118, 120, 122, 125, 128
- relation of to the Jacksonville and
mapping of, 63, 66
- thickness of, 62, 100, 113
- Anthony, log of well near, 113, 114
- Apalachicola River, exposures on and
references to, 61, 62, 65, 67, 69, 70,
98, 103, 104, 108, 111, 112.
- Appropriation for maintenance of Sur-
vey, 14-15
- Anticlinal folds, 49-50
- Argyle, marls exposed near, 125
- Artesian water, conservation of, 14
- Asphalt base oils, 43

B

- Bailey's Ferry, exposures at, 63, 98
- Baker County, 96, 124
- Ball clay, 26
- Basins, 58
- Bassler, R. S., cited, 77
- Bay County, 70, 96
- Beach sands, rare earths from, 21, 27
- Billups, G. P., 41, 126, 127
- Bituminous matter, 128
- Black, R. A., 105
- Black Creek, exposures on, 63, 100
- Boland, C. M., 105
- Bonheur Development Co., log of well
of, 77-79
- Lower Cretaceous age of limestones
from well of, 79
- Well No. 2, of, 125

- Bone Valley Formation, 64, 102, 106, 107,
112, 119
- relation of to the Alachua, 64
- Bradentown, 112
- Bradford County, 97
- Brevard County, 40, 85, 97-98
- Brick and tile, production and manufac-
ture of, 26, 27
- Brooksville area, 84
- Broward County, 98
- Bruce, log of well drilled near, 127
- Bryan, S. W., 107
- Buckman & Pritchard, 27
- Bushnell, log of well near, 80-84
- lower Cretaceous age of limestones
from well near, 84
- Butler, E. C., 41, 73
- Buttgenbach Phosphate Co., well of, 106
- Bystra, H. G., 106

C

- Cable tool method of drilling, 54
- Calhoun County, 40, 70, 98-100
- Callahan, log of well at, 115
- Caloosahatchee marl, 68, 110
- Caloosahatchee River, exposures on, 64,
110
- Cantonment, age of fossils from well
drilled near, 75
- Capillarity an influence in migration of
oil, 46
- Carbides, hydrocarbons from, 44, 45
- Carbon dioxide gas, 57
- Carrabelle, log of well near, 104
- Cates, B. M., 78
- Cavities in limestone, 106
- Cedar Keys, 111
- Cementation a factor in oil migration, 46
- Census Bureau, U. S., 20
- Central Florida Oil & Gas Co., well of,
111
- Chalcedony, 62
- Character of formations, determination
of, 58, 128
- Charlotte County, 91, 100, 102
- Charlotte Harbor, 110
- Charlton formation, 64, 66
- Chattahoochee formation, absence of in
central peninsular Florida, 61
- description and distribution of, 61, 65,
75, 77, 98, 102, 104, 108-111, 123-125
- relation of to the Marianna and the
Tampa, 61, 62, 127
- thickness of, 62

Chipley, 72, 73, 128
 Chipley Oil Co., well of, 73, 108, 128
 Chipola marl, basal Miocene, 63
 Chipola River, exposures on, 61, 63, 98, 108
 Choctawhatchee Formation, 64, 65, 110-112, 125
 Choctawhatchee River, exposures on, 64, 108, 128
 Citrus County, 60, 70, 84, 100
 Claiborne Formation, 60, 70, 72, 113
 Clarksville, log of well near, 98-100
 Clay, production of, 26
 Clay County, 63, 100
 Clays, age and thickness of the red sandy, 66-67, 109, 110, 112, 114, 116, 119
 of the Lake Region, 66-67, 107
 Clearwater, record of well at, 118-119
 Composition and properties of oil and gas, 42
 Cobb, Sam, 5
 Columbia County, 60, 80, 100, 101
 Cooke, C. Wythe, 42, 60, 61, 65, 70, 85, 108, 118, 127
 Cooke, M. K., 5
 Cooperation with U. S. Geological Survey and other Departments, 10-11, 20
 Coquina, 120
 Coral limestones, 114
 Craigin, C. I., record of well of, 92-94
 Cretaceous sediments, character of, 73, 128
 reference to, 69, 70, 73, 84, 86, 103, 110, 113, 114
 Critchlow, J. M., 40, 41, 118
 Crystal River, deep well near, 51, 100
 Cushman, J. A., identifications by, 60, 77, 79, 80, 84, 86, 91, 95, 97, 103, 113, 114
 Cuttings from wells, value of, 14

D

Dade City, deep well near, 118
 Dade County, 92, 101
 Dall, W. H., 41, 60, 62
 Darton, N. H., determination of Eocene by, 94
 Daytona, depth of Eocene at, 125
 Daytona area, 85, 125
 Deep wells, location of, 38
 DeFuniak Springs, wells drilled near, 125-126
 DeLand, exposures near, 125
 DeLeon Springs, exposures near, 125
 Depth of oil wells, 53-54

DeSoto County, 91, 102
 Diamond drill, use of, 54-55
 Distribution of formations, discussion of mapping of, 65-67
 Dixie County, 27, 61, 77, 102, 109
 Doctor's Inlet, 100
 Dolomitic limestones as reservoirs for oil, 47
 Domes, 51, 52, 79-80, 128
 Drilling conditions in Florida, 55
 Drilling for oil (see also oil) in Florida, 40
 Dundee Petroleum Co., log of well of, 80-84
 Durst, Arthur, 111
 Durst, E. A., information furnished by, 85, 95, 107
 Durst, J. A., well drilled by, 92
 Duval County, 27, 102

E

Earnings of miners, 25
 Edgar Plastic Kaolin Co., 26
 Edson, J. O., 106
 Eocene, description and mention of, 60, 67, 69, 70, 74, 76, 77, 80, 84, 85-87, 94-98, 100-102, 105, 106, 108, 110, 111, 113, 116, 118, 120, 125
 dip of in Holmes and Jackson counties, 67
 identification of in wells of Quincy Area, 76, 77
 structure of central peninsular Florida, 67, 69, 70
 thickness of in the Ocala Area, 80
 Escambia County, 39, 73, 103
 Estuarine deposits, 64
 Eucheeanna, marls exposed near, 125
 Eustis, depth to Lower Cretaceous at, 110
 Eutaw formation, 73
 Everglades, hard limestones of and mention of, 55, 98, 110
 Expenditures of the Survey, 15-19

F

Falling Water sink, 55, 73
 Faults, 50-51
 Fellsmere, exposures near, 121
 Fernandina, data from well at, 84
 Financial statement, 16-19
 Fish oil, 44
 Flagler County, 85, 103
 Flint, occurrence of, 55, 60, 62
 Florida Ice and Power Co., well of, 105
 Florida Keys, Pleistocene of the, 64, 94, 95, 114
 underground conditions on the, 94, 95

Folded strata, 49
 Formations, age and character of underlying the Cretaceous, 128
 discussion and mapping the distribution of, 65-67
 Fort DeSoto, well at, 107-108
 Fort Meade, log of well near, 119
 Fort Myers area, 91
 Fort Myers, log of well at, 91-92, 110
 Fort Pierce, exposures near and depth to Eocene at, 121
 Franklin County, 65, 75, 103
 Fresh-water deposits, 55, 64, 66, 110, 114
 Fuel used in mining, 25
 Funds of the Survey, 14, 15
 Fuller's earth, 20, 27, 62
 Future investigations of the Survey, 12

G

Gadsden County, 20, 27, 40, 66, 75, 10
 Gamble, Robert, 111
 Gardner, Julia, 118
 Gas, composition of, 42-43
 Gases, escape of from the earth, 57, 58
 Geologic distribution of oil and gas, 56
 Geologic formations of Gulf Coastal Plain, table of, 71
 Geologic formations of Florida, 59
 geographic distribution of, 60-64
 lithologic character of, 60-64
 Geologic investigations, object of, 58
 Geologic map of Florida, discussion of and reference to, 65-67
 Geologic provinces or subdivisions, 69-95
 Geologic structure favorable to oil accumulation, 47
 Geological Survey, purpose of, 6
 Geologic time table, 56
 Geology of Florida, literature relating to, 41
 Geography and vegetation of Florida, 12-13
 Georgia, extension of formations of into Florida, 67, 108
 Glades County, 91, 105
 Glass sands, 13
 Goodrich, H. B., 41, 80
 Gravels, 66
 Green Cove Springs, 100
 Greensboro, Eocene age of limestones from well near, 76
 well drilled near, 104-105
 Grove Park, exposures near, 120
 Gunter, Herman, 5, 28, 39, 118
 Gypsum in salt domes, 52

H

Hamilton County, 80, 105, 106
 structure in, 106
 Hard rock phosphate deposits, 64
 Hardee County, 91, 106
 Harper, R. M., 5
 Hastings, depth to Eocene at, 120
 Hernando County, 60, 62, 70, 84, 106
Heterostegina, 60
 Highlands County, 91, 107
 Hill, R. V., 118
 Hillsborough County, 62, 64, 70, 87, 107
 Hillsborough River, exposures on, 62, 107
 Holmes County, 67, 70, 74, 108
 Hudson, L. W., 80
 Hydrogen sulphide gas, 57
 Hydrostatic pressure, cause of oil seep, 48

I

Illinois, oil-producing formations of, 57
 Ilmenite, 27
 Immaculate Kaolin Co., 26
 Inclined porous stratum, oil accumulation in, 47-48
 Indiana, oil-producing formations of, 57
 Inorganic theory of origin of oil, 44, 45
 Iron, hydrocarbons from, 44
 Iron oxide films, 57

J

Jackson Bluff, exposures at, 63, 110, 112
 Jackson County, 31, 67, 70, 108
 Jackson Formation, equivalence of to the Ocala, 70, 72
 Jacksonville Area, 84
 Jacksonville, depth to the Eocene at, 85, 103
 exposures near, 63, 102
 log of well at, 84-85
 Jacksonville Formation, description of, 63
 discussion of mapping of, 66
 Jefferson County, 61, 65, 77, 109

K

Kaolin deposits, 26, 66, 107
 Kentucky, oil-producing formations of, 57
 Keys of Florida, Pleistocene of the, 64, 94-95
 underground conditions on, 94
 Key Largo limestone, 55, 95, 114
 Key Vaca, depth of well on, 128
 Key West, well at, 95, 114
 Key West Area, 94
 depth to Lower Cretaceous in, 95

Kissimmee Area, 86, 116
 Kissimmee Oil Co., log of well of, 116-117
 Kissimmee River, 107, 119
 Knox Still Landing, exposures near, 103
 Kribbs, G. F., 41, 116

L

Lafayette County, 61, 77, 109
 Lafayette formation, deposits referred to, 66
 Lake basins, 110, 112
 Lake Butler, well at, 124
 Lake County, 26, 27, 85, 109
 Lake County Clay Co., 26
 Lake Okeechobee, well drilled near, 86, 105
 Lake Region, mapping of formations of the, 66-67
 Lee County, 40, 91, 110
 Leon County, 40, 61, 65, 77, 110
Lepidocyclina, 60
 Levy County, 64, 80, 111
 Liberty County, 75, 111-112
 Lignite and lignitic materials, 72
 Limestones as reservoirs for oil, 44
 Limestones, production of, report on, etc., 13, 22, 28
 Literature relating to geology of Florida, 41
 Live Oak, 69, 79, 80, 123
 structure in vicinity of, 69, 79, 123, 128
 thickness of Ocala, 123
 Live Oak Area, 79-80
 Location of test wells, 128
 Long, Bartlett G., 41, 116
 Louisiana, oil-producing formations of, 56
 salt domes of, 51-52
 Lower Cretaceous, presence of in wells, 69, 73, 77, 79, 80, 84, 85, 87, 91, 9
 113, 114, 124, 125

M

Madison County, 61, 65, 77, 112
 Manatee County, 20, 27, 62, 64, 87, 112
 Manatee River, exposures on, 112
 Mapping of formations, discussion of, 65-67
 Marathon, depth to Lower Cretaceous in well at, 95, 114
 record of well at, 95
 Marianna, 74, 108, 109
 exposures near, 60, 61
 log of well at, 109
 Marianna-Chipley Area, 70, 72, 73, 128

Marianna Formation, description and distribution of, 61, 108, 125
 equivalence of to the Vicksburg, 61
 relation of to the Chattahoochee, 61, 127
 thickness of, 61
 Marion County, 60, 64, 70, 80, 85, 113, 123
 Marls, 62, 65, 91, 97, 103, 110, 115, 121, 128
 Marsh gas, 57-58
 Matson, G. C., 109
 May, Porter, 119
 Meadows, 28
 Melbourne Beach, record of well at, 98
 Methods of drilling oil wells, 54-55
 Miami, record of well near, 92
 Miami Area, 92, 118
 Miami Beach, record of wells at, 101-102
 Midway Group of Formations, 72
 Migration of oil, 46
 Mineral production, statistics on, 20-32
 Mineral water, production of, 32
 Miocene formations, references to, 62, 64-67, 69, 70, 75, 77, 80, 84, 86, 87, 95, 96, 98, 100, 102, 103-105, 107, 108, 110, 111, 113, 115, 116, 118, 120, 122-125
 Mississippi, Vicksburg formation of, 61
 Mississippian formation, oil from, 57
 Monroe County, 114, 128
 Muck, 118
 Museum of the Survey, 9

N

Nashua marl, 64, 110, 120
 Nassau County, 114-115
 New River (Franklin County), fossils from, 65, 103
 New Smyrna, depth to the Eocene at, 86
 log of well at, 86, 125
 New York, oil-producing formations of, 57
 Norwalk, salt spring near, 113

O

Oak Grove sand or marl, 63, 115
 Object of geologic investigations, 58
 Ocala Area, 80, 123
 Ocala Formation, depth to at Tiger Bay, 91
 description and distribution of, 60, 65, 70, 72, 95, 96, 102, 108, 112-114, 118, 123, 125, 127
 equivalence of to the Jackson, 71-72
 fossils abundant in, 60
 thickness of, 60, 113, 114, 123

Ocklocknee River, exposures on and mention of, 61, 63, 64, 69, 75, 77, 103, 104, 110, 111, 112, 125
 Ohio, oil-producing formations of, 57
 Ohio Well Drilling Co. (see also E. A. Durst), 91
 Oil, composition of, 42-43
 geologic distribution of, 56
 showings of reported in wells drilled in Florida, 79
 specific gravity of, 43-44
 surface indications of, 57-58
 theory of origin of, 44-45
 Oil seepage, hydrostatic pressure cause of, 48
 Oil (and gas) wells, tests drilled in Florida, 39-40
 depth of, 53-54
 method of drilling, 54-55
 Oolitic limestones, 101, 114
 Okaloosa County, 73, 103, 115
 Okeechobee, depth to and thickness of Miocene at, 86
 log of well at, 86-87, 116
 Okeechobee County, 86, 115-116
 Okefinokee Swamp, 96
 Oklahoma, oil-producing formations of, 57
 Oldsmar, well being drilled near, 118
 Oligocene formations, absence of in the Ocala Area, 80
 general references to the, 61, 65, 70, 72, 74, 75, 77, 80, 84, 87, 104, 107, 108, 111, 112, 125
 references to the of West Florida, 67, 69, 70, 72, 74, 75, 77
Operculina, 60
 Orbitoides, 89
 Orange County, 85, 116
 Orange Mills, depth to the Eocene at, 103, 120
 Organic theory of origin of oil, 44-45
 Origin of petroleum, theory of, 44-45
 Orlando, depth to the Eocene at, 116
Orthophragma, 60
 Osceola County, 86, 116

P

Pack, R. W., 48
 Palatka, depth to the Eocene at, 120
 Palm Beach, record of well at, 92-94
 depth to the Eocene at, 94, 118
 Palm Beach County, 118
 Palmetto Phosphate Co., log of well of, 87-90
 Panama City, record of well at, 97
 Paraffin base oils, 43, 44

Pasco County, 84, 118
 Peace River, 87
 Pearson Oil Co., wells drilled by, 123
 Peat, 28
 Pennsylvania, oil-producing formations of, 56, 57
 Pennsylvanian formation, 56, 57
 Pensacola, 74, 103
 Pensacola Area, 73, 74, 103
 Peppard, G. P., 91
 Perry, log of well at, 124
 Petroleum, 39, 42, 44, 128
 Phosphate, phosphatic materials, production, etc., 20, 22, 26, 28, 62, 63, 100, 106, 111, 113, 115, 119
 Pinellas County, 40, 70, 87, 118
 Pleistocene, development and distribution of, 64-66, 75, 86, 87, 91, 95, 97, 98, 100, 101, 103, 105, 107, 110, 112, 114-116, 118-120, 122, 124, 125
 Pliocene formations, references to, 64-66, 87, 91, 95, 97, 100, 102, 103, 105, 107, 110-113, 116, 118-120, 122, 125
 Plunging anticline, 50
 Polk County, 64, 87, 119
 Probabilities of petroleum production, 128
 Publications of the Survey, 6-19
 Putnam County, 26, 85, 103, 120

Q

Quincy, 76, 104
 Quincy Area, 75-76, 103
 Eocene determined from wells of, 76, 77

R

Rare earths or metals, 20, 27
 Rat Head, log of well near, 126
 Recommendations, 14
 Red Bay, exposures near, 65, 125
 Redwood, Boverton, on petroleum, 44
 Ripley Formations, 73
 Road material, marls used for, 125
 Rock Bluff, exposures at, 112
 Rock Springs (Orange County), 116
 Rotary method of drilling, 54, 55
 Roumania, salt domes of, 52

S

St. Augustine, depth to the Eocene at, 120
 St. Johns County, 85, 120
 St. Johns River, exposures on, 64, 109-110, 120, 122, 125
 St. Lucie County, 120-121
 St. Lucie Drainage Canal, marls exposed by, 118

St. Mary's River, exposures on, 64, 114
 Salt domes, 51-52
 Salt springs, 113
 Salt water from deep wells, 84, 100, 105
 Sand-lime brick, production of, 31-32
 Sands and gravels, mention of, production of, etc., 13, 31, 66, 73, 75, 97, 110
 Sands and sandstones, reservoirs for oil, 46-47
 Sanford, depth to Eocene at, 85, 122
 Santa Rosa County, 73, 121-122
 Sarasota County, 87, 122
 Sebring, well at, 101
 Seeps, oil and gas, 57, 58
 Sellards, E. H., 3, 5, 32, 119
 Selma Chalk, 73
 Seminole County, 85, 122
 Shales as source of oil, 47
 Shell marls, 62, 63, 65, 74, 75, 91, 96-98, 100, 103, 105, 108, 110, 112, 115, 116, 118, 120, 125
 Shell mounds, 122
 Shepard, J. L., 41, 105
 Sinks, 77, 80, 110, 112
 Shoal River, exposures on, 63, 115, 125
 Shoal River marl, 63
 Smith, E. A., referred to, 72, 73, 116
 Sopchoppy River, exposures on, 125
 Southern Florida, hard limestones of, 55
 Specific gravity of oil, 43-44
 influence of in migration of oil, 46
 Springs, escape of gases from, 57-58
 State Board of Health, 11
 State Department of Agriculture, 11
 State Road Department, 11
 Statistics on mineral production, 20, 26
 Stephenson, L. W., 66
 Storage of oil, 46-47
 Structural features in Florida, discussion of, 67, 69
 Structures favorable to oil accumulation, 47-53
 Structure of no significance unless formations petroliferous, 58-59
 Sulphur in salt domes, 52
 Summary of mineral production, 22, 32
 Sumter County, 39, 40, 60, 70, 80, 123, 128
 Surface indications of oil, 57-58
 Surface topography, use of in determining structure, 58
 Suwannee County, 60, 61, 79, 106, 123
 Suwannee River, 80, 102, 105, 112, 123
 structure of area between the and the Ocklocknee River, 69
 Synclines, 51, 104, 106

T

Table of geologic formations of Gulf Coastal Plain, 71
 Tallahassee, 65, 69, 110-111
 absence of Upper Cretaceous from and eastward, 69
 log of well at, 111
 Tallahassee Area, 77-79, 103, 125, 128
 structure of, 77
 Tampa, 87, 107, 119
 Tampa Area, 87
 Tampa Bay, exposures on, 62
 Tampa Formation, description and distribution of, 61, 62, 106, 107, 112, 118
 relation of to the Chattahoochee, 61, 62
 thickness of, 61
 Tarpon Springs, age of limestone near, 118
 Taylor County, 61, 124
 Tennessee, oil-producing formations of, 57
 Texas, oil-producing formations of, 56-57
 salt domes of, 51-52
 Theories as to origin and accumulation of oil, 44-45
 Tiger Bay, depth to Ocala and L. Cretaceous at, 90, 91
 log of well near, 87-91, 119
 Titanium (see ilmenite), 20
 Topographic mapping, 12
 Topography, relation of to underground structure, 58
 Trail Ridge, 97, 100, 102
 Townsend, J. A., well of, 124
 Tuscaloosa Formation, 73

U

Underground waters, conservation of, 14
 Union County, 80, 124
 United States Bureau of Soils, 11
 United States Census, 20
 United States Geological Survey, 10, 11, 12, 20, 26, 41, 42, 101, 103, 104, 107, 123
 United States National Museum, 62
 Upper Cretaceous, absence of in peninsular Florida, 60, 77, 80, 123
 probable presence of in west Florida, 73, 123

V

Vaughan, T. Wayland, 41, 103, 125
 Veatch, J. O., 66
 Vegetable oils, 44
 Vegetation, studies of, 12-13
 Vero, exposures near, 121

Vicksburg Formation, relation of to the
 Marianna, 61
 Volcanic plugs, 53
 Volusia County, 85, 125

W

Wages of miners, 25
 Wakulla County, 39, 61, 77, 78, 123, 125
 Walker Library, well record in 110
 Walton County, 40, 65, 70, 74, 103, 125-127
 Washington County, 40, 55, 67, 70, 108, 127-128
 Age and character of formations of, 127, 128
 Water powers, 12
 Well cuttings, value of, 14
 Wells drilled as tests for oil, 39-40, 111, 116, 118, 125-126
 Well records:
 Alachua Co., Alachua Ice Co., 96
 Bay Co., near Panama City, 97
 Brevard Co., Melbourne Beach, 98
 Calhoun Co., Calhoun Gas & Oil Co., 99-100
 Dade Co., Miami Beach, 101-102
 Duval Co., Jacksonville City well, 84-85
 Escambia Co., Pensacola Devel. Co., 74-75
 Franklin Co., Carrabelle Oil & Devel. Co., 104
 Gadsden Co., Owl Commercial Co., 76
 Glades Co., Fla. Ice & Power Co., 105
 Hernando Co., Buttgenbach Phos. Co., 106
 Hillsborough Co., Ft. DeSoto, 107-108
 Jackson Co., Marianna City well, 109
 Lee Co., Ft. Myers City well, 91-92
 Leon Co., Tallahassee City well, 111

Marion Co., well at Anthony, 113
 Monroe Co., Fla. East Coast Rwy., 95
 Nassau Co., well at Callahan, 115
 Okeechobee Co., Okeechobee Company, 86-87
 Osceola Co., Kissimmee Oil Co., 116-117
 Palm Beach Co., C. I. Craig, 92-94
 Pinellas Co., Clearwater City well, 119
 Polk Co., Palmetto Phos. Co., 87-90
 St. Lucie Co., Ft. Pierce City well, 121
 Seminole Co., well near Sanford, 122
 Sumter Co., Dundee Petroleum Co., 80-84
 Taylor Co., Perry City well, 124
 Volusia Co., New Smyrna City well, 86
 Wakulla Co., Bonheur Devel. Co., 78-79
 Walton Co., wells at Bruce and Rat Head, 126-127
 Well records, use of in stratigraphic work, 67
 West, G. M., 97
 West Virginia, oil-producing formations of, 57
 Wight, J. B., 41
 Wilcox Group of formations, 70, 72
 Withlacoochee River, 105, 106, 112, 118
 Wood oils, 44
 Woodville, well drilled near, 111
 Work of the Survey, 9-10

Y

Yellow River, exposures on, 63, 115

Z

Zirconium, 20

FLORIDA STATE GEOLOGICAL SURVEY
HERMAN GUNTER, STATE GEOLOGIST

GEOLOGIC MAP
OF
FLORIDA

PREPARED BY FLORIDA GEOLOGICAL SURVEY

Geology east of the Apalachicola River by E. H. Sellards and Herman Gunter,
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Scale $\frac{1}{100,000}$
Statute Miles

1922

LEGEND

PLEISTOCENE

Pip

Palm Beach limestone

Pia

Miami Oolitic limestone

Pia

Key Largo limestone

Pia

Key West limestone

Pia

Lostmans River limestone

Pia

Miocene to Recent Undifferentiated

PLIOCENE

Bone Valley formation

Pia

Charlton formation

Pia

Caloosahatchee formation

Pia

Nashua formation

Pia

MIOCENE

Choctawhatchee formation

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